CAILLETET'S APPARATUS FOR DETERMINING THE VOLUME OF GASES UNDER HIGH PRESSURE.

Condensed from a description by G. Tissandier in *La Nature*.

Shortly after Mariotte and Boyle had, at the beginning of the last century, discovered the law that "the density and volume of gases at a given temperature is directly proportional to the pressure exerted upon them," doubts were raised as to the correctness of the same with respect to different bodies and under high pressures. Twenty-seven atmospheres was the highest pressure then attainable, and the inconsistency of the results obtained, with the law promulgated, was ascribed to errors incident to the experiments. In more recent times, however, in consequence of closer scrutiny, it has been found that the law is not absolutely true. While unliquefiable gases, such as atmospheric air, hydrogen, nitrogen, etc., when exposed to moderate pressure behave in conformity to the law, liquefiable gases, like carbonic acid, sulphureted hydrogen, and ammonia, deviate from the same considerably. In most cases gases have been found more compressible than the Mariotte law indicates; hydrogen, however, is a remarkable exception, being *less* compressible.

Although Arago, Dulong, Oersted and others had already arrived at this conclusion, it was left to Regnault to demonstrate beyond doubt the incorrectness of the Mariotte law. But he also operated with a pressure of 28 atmospheres only.

Lately Mr. Cailletet, a member of the French Academy of Sciences, has paid special attention to this subject, and demonstrated by a series of experiments, made with an entirely new apparatus, the following facts: 1. The Mariotte law is not valid for high temperatures. 2. The compressibility of hydrogen diminishes in the measure as the pressure increases. 3. The maximum degree of compressibility of atmospheric air is attained under a pressure of 80 atmospheres.

In order to be able to work with a pressure unattainable by any ordinary means, Mr. Cailletet has resorted to the pressure exerted by a column of mercury contained in a tube extending from the mouth to the bottom of a deep artesian well.
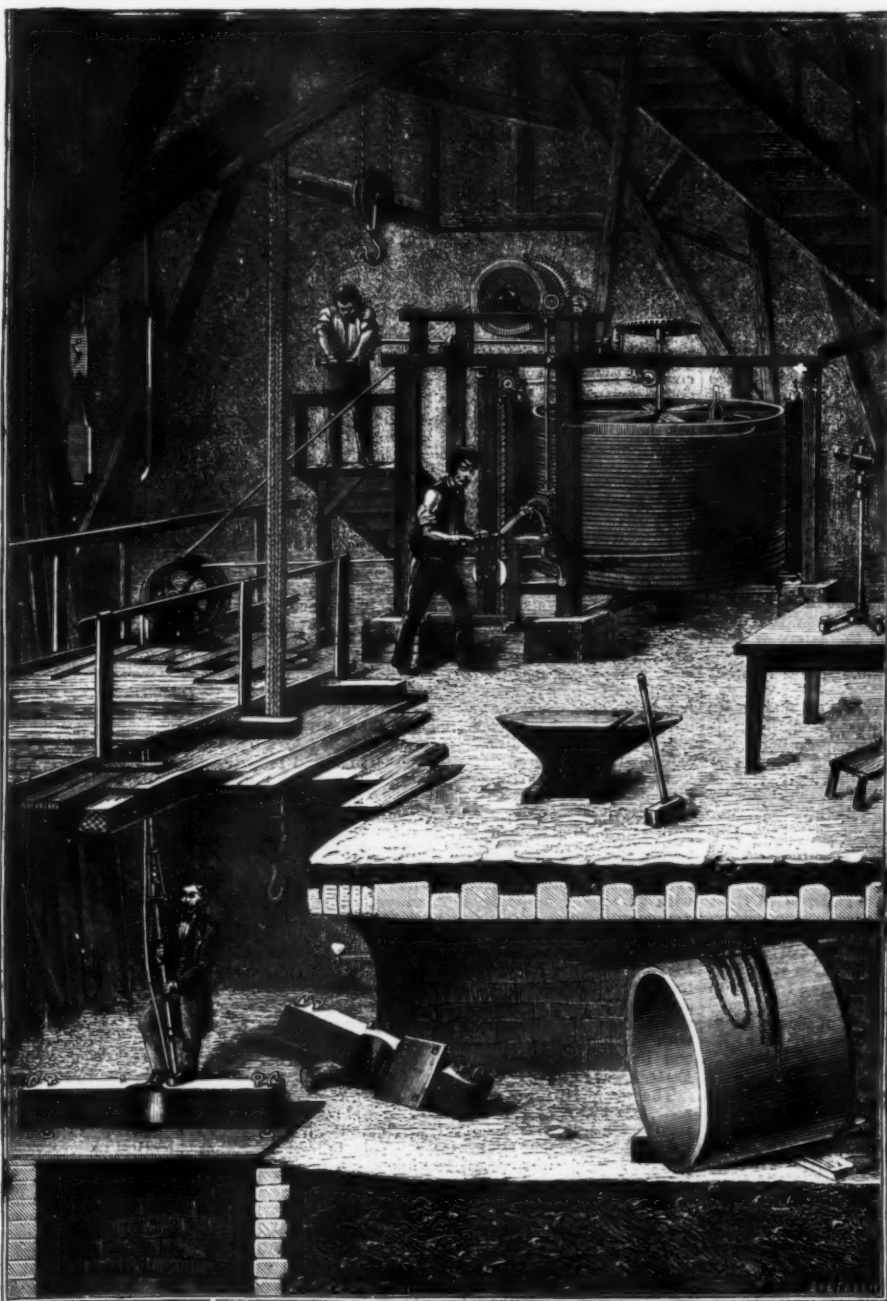
The accompanying engraving illustrates the apparatus as it is now used by Mr. Cailletet in an unfinished well bored at Butte-aux-Cailles, which is now about 1,680 feet deep and measures above four feet in diameter. The shaft has not yet reached the region from which the future supply of water is expected, but it is partially filled with stagnant water collecting from the surrounding strata.

The apparatus used by Mr. Cailletet is placed near the mouth of the shaft and protected by a wooden shed. It consists of a flexible metal tube, 750 feet in length, and wound round a drum revolving around a vertical shaft actuated by means of a crank and proper gearing. To the lower extremity of this tube is attached a steel cylinder, about four feet in length, containing a stout glass tube, closed at its lower, but open at its upper extremity, and which is to receive the gas to be tested. The cylinder connects at its lower portion with a second tube filled with mercury and leading to a manometer placed directly above the drum upon which the tube is wound. The upper portion of the tube is in its interior covered with a thin film of gold, and is tightly connected with the long flexible tube. The temperature of the depth to which the apparatus is lowered is registered by the thermometers. In order to lessen the weight to be carried by the long flexible tube, the cylinder is suspended from a graduated steel wire, wound round a drum and permitting to read off accurately the depth reached.

After the tube has been filled with the gas to be tested, it is placed in position into the cylinder, which is now closed by a hollow screw and a bolt. The air having been exhausted from the tube, and the latter filled with mercury, communication is again restored between the latter and the glass tube containing the gas, which is now compressed and reduced in volume to a degree corresponding to the height of the column of mercury pressing upon it. As the mercury enters the neck of the tube it dissolves the gold, so that after the apparatus has been raised again, the volume of the gas occupied under the pressure and temperature indicated by the manometer and thermometers respectively may be read off with accuracy.

By means of this apparatus Mr. Cailletet has already succeeded in subjecting nitrogen to the tremendous pressure of 245 atmospheres, and experiments with other gases are soon to follow. It has been found that nitrogen attains its maximum of compressibility at a pressure of 100 atmospheres, and that the compressibility declines very rapidly as soon as the pressure exceeds that point.

Mr. Cailletet has suggested the employment of nitrogen for indicating the pressure existing in steam boilers, hydraulic and atmospheric engines. Our manometers now in use are far from being correct, and the accuracy with which Mr. Cailletet has determined the volume of nitrogen under various degrees of compression would justify an experiment with a manometer, based upon the effects of pressure exerted on that gas.

Mr. Cailletet has as yet not published the results arrived at in course of his experiments, but has promised to do so at a recent meeting of the Academy of Sciences.

CAILLETET'S METHOD OF VERIFYING MARIOTTE'S LAW.

THE WIELICZKA SALT MINES.

By Chas. Grad, Alsacian Deputy to the German Reichstag.

If the reader will kindly accompany me to that remote part of the ancient Polish empire, whence come the salt supplies of central Europe, he will not find it an unpleasant journey. A branch of the Cracow-Lemberg Railway, built especially for the salt traffic, will bring us there in a few hours. The town is situated in the middle of an undulating country, the elevations of which are the outrunners of the Carpathian mountains.

The hills are crowned by splendid forests, while the valleys, slopes, and ridges look like one great farm in the highest state of cultivation. The eye rests agreeably on the deep, rich green of the meadows, and the brick tile roofs of the villages.

Arrived at the mines we have to procure a ticket of admission, for which one dollar is charged. An employe leads us to the mouth of the shaft "Kaiser Franz." Here visitors are supplied with caps and capes to protect their clothing. This is hardly necessary, however, as the mines are kept scrupulously clean. Two guides accompany us on our downward journey, which is comparatively an easy one of twenty-six flights of ten steps each. Visitors not preferring this mode of descending are lowered down the "Danielowicz" shaft by windlasses of very simple construction. To the principal rope are tied as many smaller ropes as there are visitors. At the ends of these ropes seats are provided, consisting of two cross-bars, connected by leather straps. After mounting these seats, the visitors link hands in order to steady the motion. We traverse successively layers of chalk, clay, sand, and rock, the outlines of the different strata being distinctly visible. The salt appears first at a depth of sixty feet, in veins and in single large crystals. Pumps are constantly at work to remove the water collecting in large quantities. Finally, we reach what is called the upper part or level of the mine.

The deepest portion of the mine is over 1,000 feet below the surface, 164 feet above the level of the sea. In 1866 this part, the fifth level from the surface, was flooded with water and rendered inaccessible.

A great number of galleries, shafts, tunnels, and bridges branch from and across each other here in all directions, forming a veritable labyrinth, through which the miners themselves can hardly find their way. It is impossible to give a full description of all the details of this enormous cave, dimly lighted by lanterns. When the guides call our attention to spots of particular interest, additional torches are lit to allow a clearer inspection. Passing under the Danielowicz shaft, we catch a glimpse of daylight. About thirty steps from here is located the gallery of St. Antonio, in which a horse tramway is in active operation. Next we pass into the "Hall of St. Ursula," which serves as a storeroom. After descending a flight of 120 steps we enter, through a portal of stone masonry, the great "Hall of Michaelowicz," which is 164 feet long, 92 feet wide, and 114 feet high. It contains a statue of St. Cunegunde and a large chandelier cut out of clear salt. It carries holders for three hundred candles, which, according to our guides, light insufficiently the large hall. We have to be contented with this information, as we cannot afford to pay the $500 charged for the pleasure of enjoying that sight. But even with the feebler illumination of our torches, the grand spectacle excites our admiration. In the hall of St. Ursula, the walls of salt are connected by wooden bridges, one of which leads to a door in Gothic style cut into the salt, through which we enter the hall of St. Nicholowicz.

The whole, when illuminated by colored fires, must present a fantastic appearance. A few steps more and we reach the gallery "Lichtenfels," 1,800 feet long. It communicates with the "Chamber of Drosdovicz," cut from the emerald green salt. The "Kaiser Franz" hall is situated at

60 feet distance, and we must ascend a few steps to reach it. A suspension bridge crosses the hall at a height of 82 feet, and from it we can observe the miners below, cutting and shifting blocks of salt. Two great pyramids of salt stand here, erected in memory of the visit of the Emperor of Austria in 1817. Near by is located "Rosetti Hall," containing a small lake 40 feet in depth. We cross the lake in a boat guided by wire ropes, and arrive opposite the mouth of a tunnel. Here stands a statue of Johann Nepomuk, a startling, fantastical sight in the glare of our torches.

The statues of the Wieliczka mines are entirely cut out of salt, as anybody can easily convince himself by the taste. No visitor can easily forget the "Chapel of St. Anthony." Its construction dates back to the year 1688, and formerly divine service was held here on certain holidays. The altar is built in Doric style, and is surrounded by pillars of the same order, while at the right and left are placed statues of St. Anthony and St. Clement. Two friars are kneeling on the steps leading up to the altar. The Virgin Mary is represented kneeling before a cross in a niche, handing the child Jesus to St. Anthony. Directly opposite the entrance stands a double statue representing Peter and Paul. All this is chiseled out of salt correctly, indeed artistically, being the work of centuries. When a torch is placed behind a pillar or statue, the light is visible through the mass of salt. Close by the chapel is the dancing saloon. General Souwarow, who in 1809 had his headquarters at Wieliczka for several days, gave here a ball to his officers. The salt miners dance here on holidays, and the hall is therefore provided with chandeliers, and platforms for the musicians.

The exploitation of the mines is now being carried on with the utmost care and regularity. Large galleries and bridges afford easy communication between the miners working on the same floor, while commodious staircases, partly cut in the salt, partly built of wood, connect the surface and the different levels with the remotest and deepest part of the mine. Everything bears a character entirely different from other mining structures. Although the Wieliczka Mines are, above all comparison, remarkable, interesting, and worthy of attention, the reports which have from time to time been published, and which it is needless to repeat, contain much that is exaggerated and fantastic. We will not stop to criticise the poetical accounts that have been given of whole villages of salt houses filled by a population living continually secluded from daylight, which some of the inhabitants have never seen. The truth is, that the miners leave the mine daily, only the horses remaining continually in their stables.

The mines were formerly worked under a very imperfect and defective system, without the aid of any of our modern technical apparatus. They were leased for a number of years, and that custom proved of little avail to them. The lessee tried to make all he could during his term, and he did not pay any attention to the management. Thus no precautions were taken to insure perfect safety throughout the mine for the labors of future generations. Not even the most elementary provisions were made to support the walls and ceilings of the chambers, as they were emptied, and hence they frequently collapsed. Instead of leaving a quantity of salt behind in the form of pillars, the avarice of the lessees led them to remove the entire body of salt obtainable, thus limiting the exploitation of the future in many ways. Necessity only could induce them to supply partial supports by logs and trees. The latter answered the purpose only partially, as they bent under the load and finally gave way. Besides that, fires repeatedly consumed large portions of the wooden structure, as in 1510 and 1644. Finally supports were constructed by combining blocks of salt so as to form a pretty solid form of masonry, giving perfect satisfaction.

The layers of salt adjoining the formations of rock and clay, are at present left undisturbed; thus a crust of salt is left which protects the rocky formations from the deleterious influence of the atmosphere, and the safety of even the largest excavation is at present considered perfect. Shafting in spiza salt only, which is brittle, requires different means of protection.

In opening a shaft, the upper soil is at first dug away, and the work is continued in the harder formations by drifting and blasting. For the latter, as also for blasting in the salt, only gunpowder is used. To cut out the galleries to work upon, holes are drilled in the salt so that four of them form a square, and another hole is drilled in the center of the square. On exploding a quarter of a pound of powder in each hole, a cube of about one yard in thickness is removed in several pieces. The galleries were formerly larger than now; they are at present only 122 inches high and 105 inches wide. The so-called exploring galleries run from east to west, and from them run transverse galleries at right angles at distances of from 360 to 300 feet. The miners work eight hours a day. Their wages, or rather the price paid to them for a certain cubic measure of salt or rock, varies with the hardness of the material, it ranges at present from 5 to 24 cents a cube, a day's work bringing from 50 to 75 cents.

As thus obtained, the salt is in the shape of blocks, varying in form and size according to the thickness of the bank. It enters into commerce in three different forms—"balwans," "formatstücks," and crystalline fragments. The blocks called "balwans" are in the shape of small barrels, 32 inches long and about 16 inches in diameter. They weigh generally 330 Vienna pounds. The pieces not sufficiently large to be worked into balwans are shaped in prisms 19 inches long by 7 inches in width and ten inches in thickness, weighing about 90 pounds. The workmen attending to the shaping earn 9¼ cents per balwan, and 1¼ cent for a "formatstuck." The crystalline fragments are packed in barrels. The salt is transported in the interior by small carts, running on rails, and raised to the surface by windlasses worked by horses.

According to the government reports the Wieliczka Mines furnish annually 50,000 tons of salt, half of which is consumed in Poland and Galicia. Four cities serve as staple depositories: Wieliczka, Podgoritza, Niepolomicz, Owieczin. About eight hundred men are engaged in the mine. The price ranged, at the time of my visit, from $4 for best white crystalline, to $2.63 for green salt, per 100 pounds. Bochnia, a village situated near Wieliczka, possesses also extensive salt mines. Wieliczka salt appears in three varieties: green, spiza, and szibik salt. Besides these, there is a white salt found in masses, embedded in the green variety, and is called, on account of its resemblance to ice, "sol lodowata." Then there are the natural salt gems, pure, transparent, colorless cubic or rhomboid crystals, sometimes of considerable size, found in the clay formation. In their leisure hours, the miners cut from these crystals all sorts of figures, chapels, crosses, paperweights, which they sell to visitors. Another kind, the "eagle salt," is found embedded in the gypsum layers. It is of a milky white color, and valued so highly that it was formerly reserved for use at the royal court of

Poland. Its name is derived from the fact that the barrels in which it was packed bore the Polish escutcheon with the white eagle of Poland.

The green salt is found in quantities varying in size from a cubic foot to masses containing millions of cubic yards. Ordinarily embedded in aluminous earth, its transparency varies according to the amount of earthy substances it contains. Generally it is of dark green color, resembling green glass. Its crystallization is beautiful, some crystals being 2 inches thick.

Spiza salt is generally formed at greater depths, and its strata are easily recognized by their different color. It is the hardest and densest variety of salt, but very brittle. Its texture is crystalline, showing small, short crystals, mixed with sand and petrifactions. When suspended freely and struck by a hard body, it rings like metal. It is of light gray color, and admits of. a high polish. When pulverized it emits a bituminous odor, derived from vegetable remains. The miners recognize three varieties of spiza salt, viz., Hemp salt, or "Ziemlarka;" Poppy salt, or "Makowica;" and Pearl salt, or "Jarka." The first two varieties do not generally occur in commerce.

The szibik salt is of a white to light gray color, more solid and purer than either the green or the spiza salt. Its crystals measure from ⅛ to ¼ of an inch in length, and rank, as regards size, between those of the other two kinds. Fresh water accumulates sometimes underneath the strata of szibik salt, and calls for special precautionary measures in working.

In the neighborhood of the Wieliczka Mines, as near all salt mines, the air is extremely dry, quite a contrast with the humidity reigning below. Work in the mines is never interrupted by changes in the weather. The temperature remains, summer and winter, at from 18 to 24° F. The walls, pillars, etc., wear remarkably well, some of them having stood for four centuries without showing any signs of decay. The same may be said of the woodwork. Virulent diseases are very rare among the miners, and consumptives resist the fatal effects of their disease much longer in the mines than elsewhere. Weak and reduced horses soon regain their strength when put to work in the mines.

In Galicia numerous other mines and saline springs are worked for salt. The spring at Stebnik alone furnishes 6,390 tons annually, according to Dr. Alth, of Kracovia. The salt formation is a part of the Carpathian range of mountains, running through Galicia, Hungary, and into Bukovina and Roumania. The crystallized salt is found in three zones, running parallel with the general direction of the whole mountain chain, from west to east, inclining somewhat toward the south, the Wieliczka salt occurring in the middle zone. Near the salt springs quantities of petroleum and asphaltum are found filling crevices in the rock. The sediments of gray sandstone seem to be the oldest formation in which fossils of the jurassic period are found. Directly above we find green sandstone, containing neocomian petrifactions. The next layer nearer to the surface is, by the shells it contains, found to belong to the eocenic period, and consists mostly of limestone, sand, and clay. Sandstone comes next, with veins of gypsum, calcareous slate and clay, over which lie the latest alluvial deposits. The Wieliczka salt deposits are situated in the miocenic formation, and are mostly accompanied by gypsum or clay. They commence in the gypsum of Podgoritza, south of Kracovia, and extend over Dobromil, Lacko, Starasol, to Drohobicz and Petranka.

As a whole, the salt bearing formation consists of the following parts, following each other from the surface downward: Alluvial sediments, marl and clay, sandstone, clay and gypsum, and crystallized salt. Gypsum and clay are often intimately mixed, and this is more especially the case with the highly colored clays. The gypsum is of white or reddish color, and a fibrous, more rarely finely grained, structure, not forming continued layers, but occurring throughout certain zones in round masses or nests, mostly inclosed in clay. Anhydrous gypsum of bluish color is also met with in the clay, and sometimes in the salt. Gypsum is found at Wieliczka in larger quantities than the clay, and at certain points the beds equal the salt beds in dimensions. Hydrated gypsum is found mostly in the neighborhood of the green salt, while the anhydrous is generally located between the spiza and szibik layers. Gypsum is often found mixed and massed together with fine crystalline salt, forming lumps of irregular shape.

The clay is sometimes gray, sometimes highly colored; a variety of a dirty brown color is often very rich in salt and bituminous matter. Sand and gypsum are frequently mixed with the clay, in which shells and the remains of plants are very numerous. Frequently crevices occur which are filled with an impure sulphate of magnesia. The colored clays are sometimes red, sometimes blue, very plastic and of firm consistence when dry, and do not contain any bitumen. Within the clay territory red and blue marls form oval and round nests; they are not unlike dolomite, and alternate like the colored marls of the Keuper. Through a mixture of sand and mica we pass to a sandstone of the nature of freestone, which does not show any peculiar properties in contrast with other parts of the Carpathians. It is of a bluish tint, and its stratum becomes most extensive near Starasol, in Eastern Galicia.

The green salt always forms the upper portion of the salt zone, but does not form continued layers, occurring only in irregular masses, large and small, while the two other varieties show more complete stratification. This, however, does not prevent irregularities caused by violent transposition of the layers, the latter frequently appearing broken and doubled up.

As regards the fossils, the clay has so far furnished 19 species of cytherinea, and 118 species of foraminifera, i. e., very minute shells, consisting of a number of separate chambers, connected by a small perforation, the foramen. A few also occur in the limestone of the Leitha district, the rest are peculiar to Wieliczka. As a whole, the organic remains correspond with those of the upper strata of the Vienna basin. Mr. Zeutscher reports as having lately found at Wieliczka three species of "Pecten," two of "Nacula," and one each of "Natica" and Pedipes. These all are mollusks. Of more highly developed animals there have been found only the jaws of a fish and the claws of a lobster.

The spiza salt incloses six species of zoophytes or polyps, and fourteen of polythalumia (also many chambered shells', eight univalves and three crustacea, several of which are still met with alive in the Mediterranean.

To this must be added the following plants determined by Dr. Stur: Three peculiar species of Pines, one species of Beech, one each of "Raphia," "Pinites," "Phytoxylum." "Taxoxylon," "Birch," "Fegonium," "Liquidamber." "Pavia," "Cassia," and three of "Carya." These plants would place the time of formation of the Wieliczka deposit within the tertiary period.

Pine tree cones, carya nuts, and trunks of beech trees are

frequently found. Masses of crystalline salt often inclose the fruits of the Conifera, in which the kernels are missing. In all probability streams of water issuing during the tertiary period from the huge forest of the Carpathians carried these fruits, deprived of their kernels perhaps by animals similar to our squirrels, into lakes, analogous to those found at the present day in other countries, and of which these salt deposits form the residue.

FRAGRANT WOODS.

The properties and uses of woods are various ; some are sought for their beauty and utility for the cabinetmaker or pianoforte manufacturer, some for their adaptability for carving or engraving on, others for their coloring properties, and some for their medicinal uses. There are a few, however, which have the rare attraction of being fragrant and odorous, and hence are valued for small and special fancy articles for ladies' use, or for the purposes of the perfumer, who distills pleasant scents from them. Although fragrant odors are very generally diffused over the vegetable kingdom, yet they are not often centered in the woody fiber of plants. We know these odors well in flowers, and we find them strongly diffused in many aromatic leaves, as the lemon and citronelle grasses, the leaves of the Faham orchid (Angræcum fragrans), and of the Eucalyptus citriodora, and E. odorata. Sometimes the pleasant odor or pungent flavor is concentrated in the seeds and seed-vessels, as in the nutmeg, the tonquin bean (Dipteris odorata), the musk seed (Abelmoschus moschatus), the odoriferous seeds of Oxydendron Cuyumany (Nees), the vanilla pods, and those of Myrospermum frutescens (Jacq.), etc., of South America. In several trees the aromatic principle is strongest in the barks, as in cassia and cinnamon, the sassafras of Tasmania (Atherosperma moschata), and Croton cascarilla and C. eleutheria, of the Bahamas. Essential oils are obtained from many of these.

The study and consideration of woods may be influenced by many causes, according to the purposes to which they are to be applied. The cabinet-maker will group them according to the disposition of their colors and the distinction of their fibers, and will sometimes also take into consideration the odor, which is an essential point in the eyes of the perfumer. As I do not remember to have seen any grouping of the fragrant or odorous woods, I propose condensing a few observations as a guide to those who may be interested in this class of woods, which is not, after all, extensive, and only a few of which are as yet much used. Two or three are tolerably well known, such as camphor, sandal, and cedar woods ; others have not been so generally described.

The bark of Ocotea aromatica, from New Caledonia, possesses a strong sassafras flavor, and there is a fragrant bark yielded by the Alyzia aromatica, of Java and Cochin China ; but as I have not met with specimens, I cannot tell whether the odor penetrates to the wood. The Ixora (Coffea) odorata of Tahiti has, however, I know, a close and fragrant wood.

In Tasmania and Australia we have the musk-wood (Eurybia argophylla), with a timber of a pleasant fragrance and a mottled color, well adapted to turnery, cabinet work and perfumery purposes. The native box-wood (Bursaria spinosa, Cav.) has also a pleasant but fleeting scent. The scent-wood of the same island (Alyzia buxifolia, R. Br.) has an odor similar to that of the tonquin bean. It is but a straggling sea-side shrub of three to five inches in diameter, and consequently does not produce wood of any size, but it is fine and close-grained, of a lightish brown mottled appearance.

In the colony of Western Australia we have the raspberry-jam wood, a species of Eucalyptus, which derives its popular name from the similarity of the scent to that preserve. It is a handsome wood, well fitted for cabinet purposes.

Many of the Australian woods exhibit a peculiar beauty of structure, which adapts them for small furniture and turnery uses. Some are highly fragrant, and retain their agreeable odor for a considerable period of time, which renders them additionally pleasant and acceptable in the form of ornamental articles for the boudoir and drawing-room. The scented myall (Acacia homalophylla) is a very hard and heavy wood, which has an intense and delightful smell of violets. It has a dark and beautiful duramen, which makes it applicable to numerous purposes of the cabinetmaker and the wood turner, and an infinite variety of minor uses. It rarely exceeds a foot in diameter, but has been used as veneers. This tree is common in many parts of Australia ; since the London Exhibition of 1862, when the caskets, pipes, and other articles shown from Queensland, and the remarkable property it possesses, became generally known to European manufacturers, the wood has been in request for making glove, handkerchief, and other fancy boxes. As long as it remains unpolished, it preserves this peculiar fragrance of violets, which does not occur with such perfection in any other known substance.

The desert sandarac pine (Callitris verrucosa) is a tree of moderate size, from the vicinity of the river Murray, seldom attaining to more than 18 inches in diameter. It has a peculiar odor, from which it is sometimes called camphor-wood, and is said to be obnoxious to the attacks of insects. The dark beauty of its wood makes it useful for many articles of small cabinet furniture. The mountain sandarac pine, another species similar to the preceding one, is available for identical uses.

The sassafras tree (Atherosperma moschata) has an aromatic bark, which yields an essential oil, resembling the sassafras oil of America, with an admixture of oil of caraways. The timber, which is useful to the cabinetmaker, has a dark duramen, and frequently exhibits a pleasant figure ; it has also the quality of taking a beautiful polish. Sassafras-wood (Sassafras officinale), which is brought over from North America in billets, is highly aromatic, both in smell and taste, owing to a yellow volatile oil it contains. As this repels insects, the wood is used in India for the interior work of trunks, drawers, boxes, etc.

Brazilian sassafras is the aromatic bark of Nectandra cymbarum (Nees). The fragrant bark of the swamp sassafras of the United States (Magnolia glauca) is greatly sought by beavers, and hence is often called beaver-wood. A common deception is much practiced in the streets of London in selling artificially scented woods and roots which have been steeped in citronelle and other pleasant essential oils.

The sandal-wood of commerce is the product of various trees belonging to the genus Santalum, and that species called Santalum album for a long time furnished the principal supply. Being a hard, close-grained, and ornamental wood, it is used for some descriptions of cabinet work, and various carved ornamental and useful articles, such as fans, writing desks, work boxes, card cases, album covers, etc., are made of it. But its chief characteristic consists in the remarkable smell of the wood, which it owes to the pre

ence of a peculiar volatile oil, extensively used by the natives of India as a perfume. This also has caused it to be largely used as incense to burn in the temples of China.

The roots, which are the richest in oil, and the chips go to the still, while Hindoos who can afford it show their wealth and respect for their departed relatives by adding sticks of sandal-wood to the funeral pile. The wood, either in powder or rubbed up into a paste, is employed by all Bramins in the pigments used in their distinguishing caste marks. The oil forms the basis of many scents, and is sometimes used for impregnating with its scent articles which, being really carved from common wood, are passed off as if made from true sandal.

In course of time sandal-wood was discovered to be abundant in some of the South Sea Islands, where it is the product of several species of *Santalum*, different from the long-known Indian one; there are about ten species of the genus, which are chiefly restricted to the East Indies, Australia, and Oceania.

The Indian species are *Santalum album* and *S. myrtifolium.*

from 7,500 to 8,000 piculs (1½ cwt.) of sandal-wood, valued at about £14,000, were imported into Canton, within the last four or five years it has dropped to 20 or 30 piculs.

At Chefoo it is still imported to the extent of 530 piculs, and the general imports into the treaty ports amounted in 1872 to 64,237 piculs.

In Europe sandal-wood is chiefly used for carving and turning. In the Indian Museum, South Kensington, specimens of the ornamental application of sandal-wood in the East may be seen in boxes inlaid with ivory, a handsome carved sandal-wood table from Bombay, and other articles.

The Australian species of sandal-wood are believed to be derived from *S. lanceolatum, oblongatum, obtusifolium, oratum*, and *cenosum*. The tree is found in Queensland and Western Australia. At the London International Exhibition of 1862 a fine log of sandal-wood, weighing 4½ cwt., was shown from Blackwood River, Western Australia; and another, 3 feet 6 inches long by 11 inches diameter from York. Specimens were also shown at Paris in 1878. The Australian sandal-wood is of an inferior quality as regards odor.

In 1849 1,204 tons of sandal-wood, valued at £10,711, were

are cut into lengths of from 3 to 6 feet, and the whole of the bark and outer white wood are chipped off with the ax—an operation technically called "cleaning." Thus a log 1 foot in diameter is reduced to a billet only from 4 to 6 inches thick. The quality of the wood depends on the quantity of the oil contained in it, as indicated by the smell when freshly cut or burned. The old trees produce the best, and in them that part of the wood near the root is the most prized. A handful of shavings of the wood will prevent moths from attacking clothes of any description; and I have successfully used the same means to keep away insects from specimens of natural history. Owing to a similar strong aromatic odor, furniture made of the fragrant timber of the bastard sandal-wood of Australia (*Erimophila Mitchellii*, Bentham), may be kept free from the attacks of insects. The wood is hard, of a brown color, nicely waved and beautifully grained. It will turn out handsome veneers for the cabinetmakers.

S. Austro-Caledonicum (Viell.), of new Caledonia, furnishes a superior kind of sandal-wood to that of other countries, owing to the strength and fineness of its odor. It is to be regretted, however, that this tree is being ruthlessly destroyed in the island, as the wood is of such great use in perfumery. Scarcely anything but the stumps and roots left from former times can now be utilized. An essential oil, distilled in England and France from sandal-wood, fetches £3 per pound. The powdered wood for filling sachets and for other uses is sold at 1s. the pound. The Pacific species of sandal-wood are *S. ellipticum* and *S. Freycinetianum* (Gaudichaud), which are met with in the Sandwich Islands. The latter species is found in the high mountainous ranges of Tahiti; but the wood is of inferior quality, as it is not odoriferous, or only becomes so by age. The wood of *Myoporum tumifolium* (Forster), is used as a substitute for sandalwood; the fragrance of the fresh wood is very pleasant, but it soon loses this after being kept some time.

The cedar-wood chiefly imported is *Cedrela odorata* from Cuba, Mexico, and Central America, in quantities varying from 3,000 to 5,000 tons yearly; and the red or pencil cedar of Virginia and Bermuda, *Juniperus Virginiana*. Fragrant cedrine, an essential oil, is distilled from the wood. The cedar-wood of British Guiana (*Icica altissima*, Aubl.) has also a strong aromatic odor which keeps away insects, and adapts it for cabinets, wardrobes, etc. In the translation of Latin authors, the citron-wood has been often quoted for the cedar, without taking into account the difference which Pliny makes between the two woods. "*Cedri* tantum et *citri* suorum fructicum in sacris fumo convolutum nidorem noverant," etc.—Pliny's "Natural History," Book xiii. And the description which Theophrastus gives of the Thuya and Homer cites in his "Odyssey:" "A great fire burnt on the hearth, the odor of the cedar which is easily split, and of the Thuya which was consumed, spread widely over the island."

Pinus Cembra of Russia is another of the fragrant woods.

The fragrant rosewood or Palisandre of the French cabinetmakers, has been ascertained by M. Brogel to belong to two or three species of *Triptolomea*.

An undefined rare wood from South America, called *Palo santo*, has a fine odor, which it never loses. It takes a magnificent polish, is of a green color, very solid and elastic. It may be used for furniture, wind instruments, and would make magnificent pianos. A log brought down the river to Parana some years ago measured 27 feet in length, with a section of 17 inches square. The violet wood of British Guiana (*Andira violacea*) derives its specific name more from its color than its scent.

In Japan they use the wood of a small tree called *camaboc* largely for making toothpicks, which is of itself quite a trade in that country. The bark has a peculiar and pleasant aromatic flavor. A small portion of the bark is allowed to remain on each toothpick. All the Japanese use them regularly after every meal.

The odor of the cinnamon-wood is familiar in domestic economy.

The camphor-wood boxes brought from China and the East are well known for their strong preservative odor, and found useful for keeping away moths from woolens and furs. The China and Japan camphor tree (*Cinnamomum camphora*), *Camphora officinarum*, belongs to the laurel family, but that of Sumatra and Borneo is the *Dryobalanops aromatica*. Even the leaves and fruit smell of camphor. In Sumatra this tree is abundantly met with on the west coast, chiefly in the extensive bush, but seldom in places more than 1,000 feet above the level of the sea. The tree is straight, extraordinarily tall, and has a gigantic crown which often overtops the other woody giants by 100 feet or so. The stem is sometimes twenty feet thick. The barus camphor of this island is the most esteemed of any, and it is for this drug, obtained in but small quantities—seldom more than half a pound to a tree—that it is ruthlessly destroyed. The tree, when felled, is divided into small pieces, and these are afterwards split; upon which the camphor, which is found in hollows or crevices in the body of the tree, and above all, in knots or swellings of branches from the trunks, becomes visible in the form of granules or grains. An essential oil also exudes from the tree in cutting, which is sometimes collected, but it is scarcely remunerative. On the west coast of Formosa there are forests of camphor-wood, and a great deal of crude camphor is shipped thence to Amoy and other Chinese ports. Large quantities of the wood are sawn into planks. Tables and cabinets are then made of it, and it is also turned into platters and washing basins.

Only a small portion of the vast camphor forest of Formosa has been reclaimed from its wild inhabitants, and this consists of fine tall trees, the growth of ages. When a tree is felled, the finest part of the wood is sawn into planks, the rest chopped small and boiled down for the camphor.

Camphor-wood (*D. aromatica*) grows in abundance in the mountains of Santerborg, Marang, Sunda, and Surgany Water, Borneo. Its girth reaches 17 or 18 ft., and the stem often attains the height of 90 or 100 feet to the first branches. The wood contains a quantity of oil, is tough, durable, and, owing to its strong scent, withstands the attacks of the worm so destructive in those seas. Hence it is much valued for shipbuilding. It takes metal fastenings well from being oily, and iron has been found not so liable to rust in it.

An essential oil of roses from some undefined wood, called *Aspalathum* (probably a convolvulus or species of *Rhodosira*), is distilled in France and Germany, and sells at about £3 the pound. There is a wood which comes from French Guiana, called there *Bois de rose femelle*, believed to be the produce of *Licaria odorata*, which has a delicious odor approaching to bergamot; but being extremely fugitive, it is necessary to pulverize the wood at the moment of distillation. The essence drawn from it is now employed by the Parisian perfumers. It is a coarse-grained, yellow wood, and scarcely ornamental enough to be sought for cabinet work.

The lignum aloes, garoe, calambak, or eagle-wood of commerce, is of all perfumes that most esteemed by Orien-
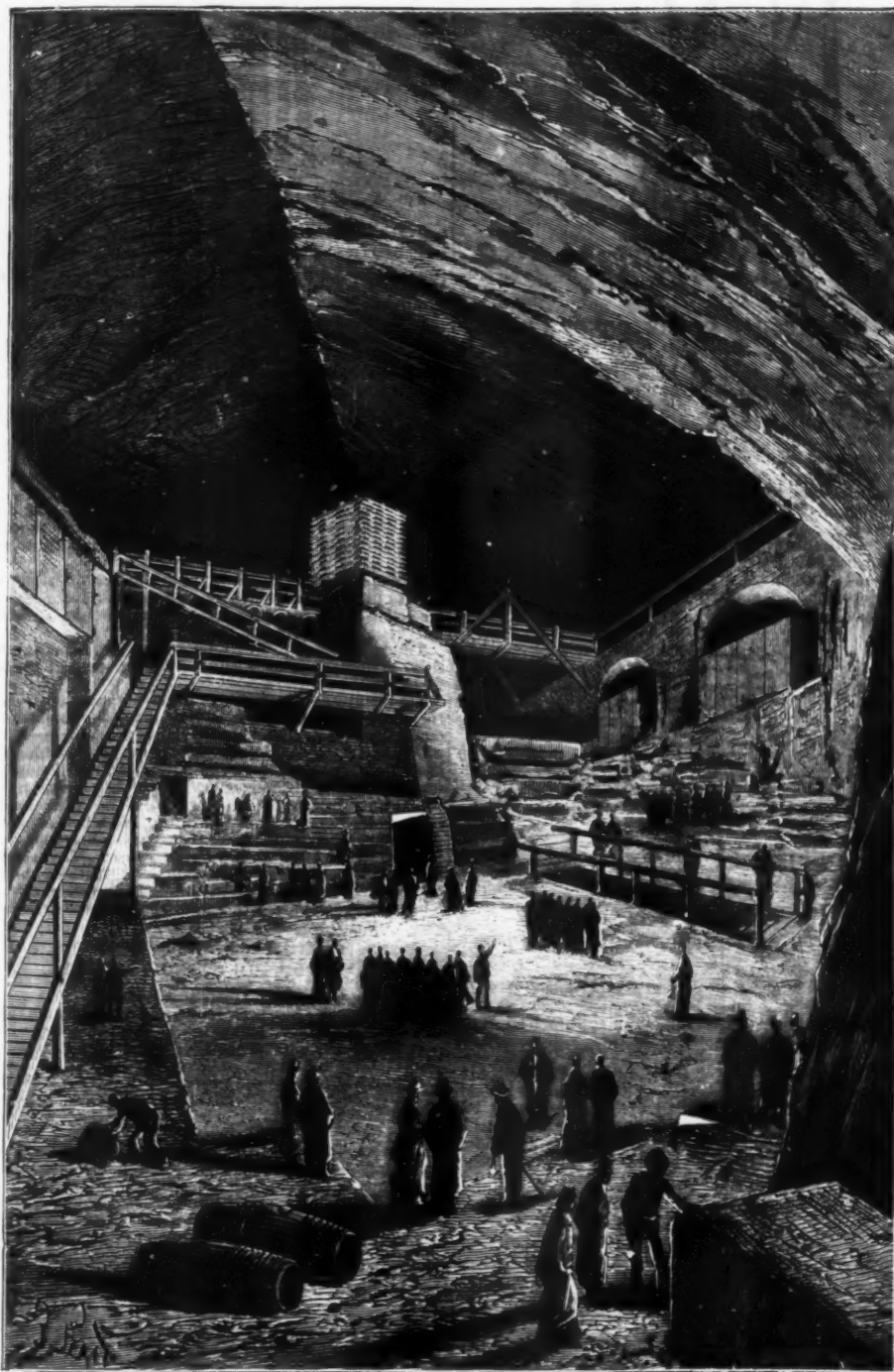
THE GREAT SALT MINES OF WIELICZKA, POLAND.

The former is a small tree from twenty to twenty-five feet high, which is found on the border of Wynaad in the Peninsula and in Mysore. The exports of the wood from Madras are considerable to Bombay, Bengal, Pegu, and the Persian Gulf. The wood is burnt to perfume temples and dwelling-houses. The same tree yields both the white and yellow sandal-wood, the last being the inner part of the tree; it is very hard and fragrant, especially near the roof. The Mohammedans obtain a precious oil from the moist yellow part of the wood, which they value as a perfume. Large shipments of it are made to Bombay, Bengal, and the Persian Gulf. The tree grows in the islands of Sandal, Timor, Rotti, Savul, Samar, Bali, and in the eastern part of Java, in the arid soil of the lower regions. The wood, which in its color and texture resembles boxwood, is much sought for as an article of commerce by the Chinese, who use the saw-dust for making rings and pastilles for burning, and also for marking the time passed during combustion, when it exhales an agreeable odor.

Mixed with some chemical preparation, the sawdust is often used in scent-bags, which hang as charms to the women's dresses. The imports of sandal-wood into China have, however, of late years, almost ceased. While in 1862 and 1863,

shipped from Western Australia. The merchants bought it for shipment at £6 to £6 10s. a ton. Now the sandal trees of any size, within a radius of a hundred and fifty miles of Perth, have been cut down, and little can be obtained except from a great distance. In 1876 7,000 tons were exported, of the estimated value of £70,000.

How long the colony may be able to continue to supply at the rate the trade is being carried on at present is another question, and a very serious one. Every year the expense of carriage becomes considerably enhanced by reason of the larger distance to be traversed, and the supply in some localities is altogether exhausted.

It is probable that there are several distinct species of the tree in the South Sea Islands which have yet to be botanically determined. The tree is not found on all the islands of the Pacific; its headquarters would appear to be among those of the southwestern portion, including New Caledonia, the Loyalty Islands, New Hebrides, Espirito Santo, and some others. In the Fiji Islands, which have produced several thousand tons within the last thirty years, the tree has become very scarce. It is only the central portion of the tree which produces the scented yellow wood constituting the sandal-wood of commerce. The trunk and larger branches

tal nations. The trees from which it is obtained are not well defined. The best is supposed to be from *Aleoxylon Agallochum* (Lour.) of Cochin China ; while the *Aquilaria ovata* (Cav.), and *A. Agallocha* (Roxb.), of tropical Asia, furnish, it is believed, other kinds of aloe-wood. All are highly fragrant and aromatic, and occasionally used by cabinet-makers and inlayers.

Aquilaria Agallocha (Roxb.) is a medium-sized tree growing in Borneo, Sumatra, and Java in the high regions. The wood is compact, of a yellow color, streaked with black. By rubbing, however, it only gives forth an odor of rhubarb, which is also palpable in slicing the wood. The most esteemed kinds of this wood are obtained from the mountainous countries of Cambodia and Cochin China, to the east of the Gulf of Siam. It is the decaying old heart-wood which is burnt for perfume.

Incense wood is the fragrant product of *Icica guyanensis*.

In conclusion it may be added that, while some woods attract by their pleasant odor, others are so obnoxious that they have obtained the appropriate names of stink-woods. Of this we have an example in the stink-wood of the Cape of Good Hope (*Laurus bullata*), which has a very disagreeable smell when cut ; hence its vernacular name. The brown-colored wood is durable, takes a good polish, and might probably be employed for cabinets for natural history collections, as it is not attacked by insects.—P. I. S., *in Journal of Applied Science.*

[Continued from SUPPLEMENT No. 159.]

A STUDY OF WHEAT.

By MRS. LOU REED STOWELL.

THE MICROSCOPICAL STRUCTURE OF THE DIFFERENT COATS.

WOULD you believe there was any great complexity in the structure of a grain of wheat in looking at it with the naked eye ?—for certainly it looks like the most simple thing in the world. Yet that very little grain possesses a mechanism even more complicated and curious than the structure of the most elaborate machinery. It would be impossible to produce it artificially. No mechanical work would be able to produce the delicate tracings or the minute cell divisions which the microscope shows to be so beautiful. Neither could it produce the nearly transparent covering, so delicate, so thin, and yet so strong and tough as to bravely withstand the effects of moisture. That the wheat is minute as well as intricate in its structure, we shall see before we are through with this study.

A grain of wheat is oval or egg shaped, with a deep longitudinal furrow on the inner face ; with a keel or irregularly curved surface covering the embryo on the back near the base of the grain, and with quite a heavy growth of vegetable hairs at the opposite end or the apex. It must be remembered that a grain of wheat is not a seed, as so many

FIG. 1.—EPIDERMIS OR FIRST FRUIT-COAT OF WHEAT.

think, but rather a perfect fruit inclosing the seed within itself, so necessarily its structure is more complex. Starting from the outside of the kernel, let us see what different structures we find before reaching the center. First, there are three fruit-coats, known as the first, second, and third fruit-coats; then there are two seed-coats, known as the first and second seed-coats—which make five distinct coats surrounding a grain of wheat, which, taken altogether, have a thickness of less than 1-15 of a millimeter (1-400 of an inch). Then we come to a coat as thick or thicker than these five coats, surrounding the white or central part of the grain, and containing the nitrogenous substances. Then the whole central mass of the grain loaded with starch, and last the embryo at the base. It may make this clearer if the different parts are tabulated as follows:

FRUIT-COATS, OR PERICARP.

1. Outer fruit-coat, or epidermis, or exocarp.
2. Middle fruit-coat, or mesocarp.
3. Inner fruit-coat, or endocarp.
4. Vascular bundle.

SEED-COATS.

5. Outer seed-coat, or testa.
6. Inner seed-coat, or endopleura.

ALBUMEN.

7. A single layer of large cells filled with gluten and nitrogenous products—perisperm.
8. Large hexagonal cells filling the central part of the grain and loaded with starch, etc.—endosperm.

EMBRYO.

9. A single layer of empty compressed cells.
10. Regular hexagonal cells of the embryo filled with starch, oil, etc.

As we understand the term "bran," it includes the first seven of these parts, that is, all the different coats of the wheat.

1. The outer fruit-coat, or the epidermis, consists of a single layer of cells—see Fig. 1—similar in appearance to those found in the epidermis of the straw—long, narrow cells with a strong cell-wall, looking something like a string of beads. An important thing to remember is that the longest way of the cells is with the length of the grain. About the center, that is, midway between the two ends on the surface, these cells are in length nearly three times the width, while as they approach either end they gradually grow shorter and rounder. Occasionally stomates are found in the epidermis, but not regularly as in the straw. At the apex of the grain, and

growing out from this layer of cells, are the long slender hairs seen in Fig. 2; A shows the epidermis, and the way the hairs are embedded in the cells. These hairs are composed of a single cell with very thin cell-walls, which leaves quite a cavity in the center, as seen at B. This cavity in all probability is filled with gas of some kind, and if we estimate several hundred of these hairs on each grain of wheat, which is by no means too large an estimate, would it not be right to wonder if the breaking up of these hairs and the escaping of the gas might not be sufficient to explain some of the mill explosions of the present time ? With this thought in mind we obtained, a short time since, some of

FIG. 2.—HAIRS FOUND AT THE END OF A WHEAT KERNEL.

the dressings left after the flour had passed through a middlings purifier, and were surprised to find such a large per cent. of the mass to consist of these hairs. Nearly half of the entire quantity was composed of these fine, delicate hairs, that are so light and inflammable. Chemistry teaches us that almost any dry material, when powdered and mixed with air in just the right proportion, will explode if a flame is brought near. Now these hairs are so light and dry that they float in the air easily, and they burn very readily when thrown into the air over a gas jet. If chance has mixed this dry powder at just the right proportion with air for an explosion, and if chance has brought a lighted lantern or a flame of any kind in contact with the mixture, who can say what would be the result ?
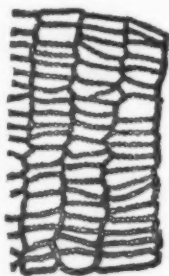

FIG. 3.—THIRD FRUIT-COAT OF WHEAT.

Certainly the subject is well worth experimenting with, and the miller is in a much better position to do this than the scientist, for he is acquainted with all the practical workings of the mill, and familiar with all the questions of mill explosions.

2. The middle fruit-coat, or mesocarp, as called by botanists, is made up of several layers of longitudinally extended cells, similar in appearance to the first coat, only not beaded so strongly. The walls are more delicate, cells a trifle wider and closely adherent to each other and to the epidermis. It is almost impossible to separate these two coats without the aid of reagents.
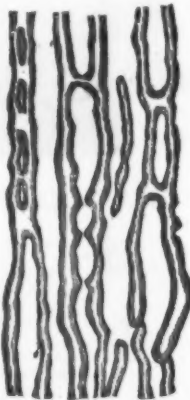

FIG. 4.—CANALS FOUND ON THE INNER SURFACE OF THE THIRD FRUIT-COAT OF WHEAT.

3. The inner fruit-coat or endocarp is composed of long, narrow cells similar to those of the first coat, only lying at right angles to them, that is, the longest way of the cells lies crossways of the grain. (See Fig. 3.) They are from 1-150 to 1-300 of an inch in length. The walls are more finely beaded, presenting a stronger appearance than in the outer fruit-coat. It is almost impossible to mistake any of these coats under a microscope, or even to get them confused, for they are generally together, and are always the same, whether you find them in flour in studying the structure of

the grain, or, as is too often the case, when we find them where wheat has been used as an adulteration of some ground spice or drug. The three coats lie together, but in one direction we see only one layer of cells, while in the opposite we find three or more. The single layer is the third fruit-coat, while the others are the second and first. On the underside of this fruit-coat, and attached firmly to it, are found very peculiar canals, frequently anastomosing, and having thick walls. They run lengthwise of the grain, and in this way give great strength to the fruit-coats. (See Fig. 4.) What remarkable provisions for strength we see in the way these three fruit-coats are arranged!

4. If you take a grain of wheat and break it open longitudinally, breaking it in the crease made by the deep groove, and examine the edges as they fold over in this groove, you will find a line of a deeper color than the rest of the wheat grain. If this dark line be taken out and treated with potassic hydrate and examined under the microscope, a delicate vascular bundle will be seen. (See Fig.

FIG. 5.—SPIRAL VESSELS FOUND IN WHEAT.

5.) Another sign of strength in the grain. The spiral vessels are seen plainly as they uncoil under the action of the reagent, and seen on either side of the figure. This vascular bundle is seen plainer near the center of the grain than at either end.

5. We have divested our grain of its fruit-coats, and have now nothing except the seed left. There are two seed-coats, made up of long, slender cells, with very thin, nearly transparent cell walls. The cells of the coats cross each other at right angles. The outer seed-coat or testa is the coat which furnishes the coloring matter, and decides whether the grain shall be red, yellow, or white. The coloring matter exists in little roundish masses, seen in greater quantities on the surface of the grain which is protected by the deep groove, or near a vascular bundle. If there are none of these little masses of coloring matter present in the coat, the wheat is white: if there is a great quantity, the wheat is of the red variety; and between these come the different quantities, and in proportion to the amount, the wheat is light or dark yellow.

6. The second seed-coat is similar to the first, only wanting the pigment or coloring matter. The cells of both coats are collapsed and hard to demonstrate, and not of sufficient importance to illustrate.

Thinking some of our readers might like to make some of these examinations themselves, we give some of the details of the work.

Let the grains soak in warm water for about twelve hours, then hold a grain on the end of a needle which has been wedged into a wooden handle, and with another needle pick off carefully the outer fruit-coat, and examine with a microscope. It is so coarse as to be seen readily with a magnifying power of fifty diameters. After this it should be examined with a higher magnifying power in order to see the beaded structure. After removing carefully the epidermis, place the grains back in the water, and allow them to soak from twelve to twenty-four hours longer. The second and third fruit-coats can now be examined. If these are picked off carefully, and the grain allowed to soak a few hours longer, the remaining structures can be separated and examined.—*American Miller.*

A GOOD MOUNTING MATERIAL.

By FRANCIS DANN.

THE following has been found an excellent mounting material for both carbon and silver prints. It is very adhesive, does not *penetrate* the paper nor destroy the brilliancy of the prints, and is convenient to use.

Dissolve 16 ounces of good French glue in 30 ounces of water, to which add 80 grains of shellac dissolved in one ounce of methylated spirit, and stir them well together while hot.

Dissolve 6 ounces of dextrine in 8 ounces of methylated spirit and 4 ounces of water; stir well together in a glass beaker, and place it in a saucepan of hot water until dissolved, and of a clear brown color, when it must be added and well stirred with the glue.

The above quantity may safely be made and poured into a dish or mould for use when required, pieces being cut therefrom as necessary. It is made ready for use by applying heat sufficient to liquefy it.

NEW PYROMETERS.

THE accompanying engravings illustrate two new pyrometers, patented recently by the Messrs. Zobel & Co., and Steinle & Harburg, respectively, both of Quedlinburg, Germany.

The Zobel pyrometer, illustrated by Figs. 1, 2, and 3, is based upon the difference in the degree of expansion produced on different metals by heat. It consists of two concentric metal cylinders, *a* and *b*, inclosing two concentric brass tubes, *c* and *d*, connected each at the upper extremities with a lever acting on one arm of an index hand placed before a dial. The tube, *d*, is shorter than the tube, *c*, its lower portion being replaced by a steel tube, *e*, of corresponding length. When the lower portion of the instrument is brought into the liquid or gas, the temperature of which is to be measured, the tubes, *c* and *d*, expand, the increase in length being proportionate to their size. If they were equally long they would exert an equal pressure on both arms of the dial hand lever. But, as the lower portion of the tube, *d*, has been supplanted by the steel tube, *e*, and as steel does not expand when exposed to heat in the same proportion as brass, the tube, *c*, will become longer than the tubes, *d* and *e*, combined, and will consequently act on the index hand.

Holes, *f f*, permit free circulation of hot air around the tubes. The holes are closed by filters, *g*, consisting of pieces of sponge inclosed between wire screens, to prevent moisture and dust from entering the apparatus. The filters form part of round disks screwed to the cylinder, *a*, which may be removed and permit the apparatus to be properly regulated by turning a screw.

Steinle & Harburg's pyrometer is represented by Fig. 4. It consists of a metal cylinder, *a*, carrying at its upper extremity a dial and index hand, *b*. It incloses two perforated tubes, *c* and *d*. The lower portion, *l*, of the tube, *c*, contains a bar of graphite, *g*, which is firmly attached to the movable tube, *d*, at *u*, and is also secured to the bottom of the tube, *a*. The tube, *d*, has its upper extremity connected with a lever acting on the index hand. When the apparatus is exposed to the heat, the metal cylinder, *a*, as well as the tubes, *c* and *d*, expand. The increase in length of the cylinder, *a*, is of no consequence. When the tube, *c*, expands, the increase in length must, by reason of its peculiar attachment, take place at its lower extremity, *l*. It carries along the graphite
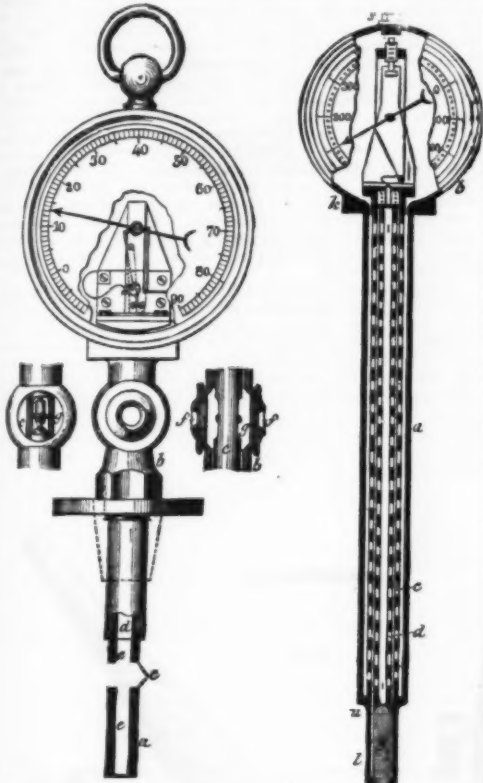

FIG. 3.   FIG. 1.   FIG. 2.   FIG. 4.

A NEW PYROMETER.

bar, *g*, the length of which is less affected by heat than that of a metal tube ot corresponding length. The tube, *d*, being shorter than the tube, *c*, increases less in length, and it consequently pulls on the lever acting on the index hand, which is turned through a distance corresponding to the degree of heat applied.

Suitable openings allow the air to enter the apparatus, and the perforations of the tubes permit the same to circulate freely. The index hand and the levers may be brought into proper position by means of a key inserted through an opening ordinarily closed by the screw *s*.—*Bulletin du Musée de l'Industrie*.

LIGHT DRAUGHT, FAST, STERN WHEEL STEAM YACHT.

To the Editor of the Scientific American :

I have read with interest several articles on steam launches appearing from time to time in the SCIENTIFIC AMERICAN, and wish to describe some differing in many respects from those you have described and illustrated. The boats were built for United States surveying parties at work on the Mississippi River, between St. Paul and Grafton, and were designed under the direction of the United States engineer officer stationed at Rock Island, Ill. They were to be small, of very light draught, and cheap, and to be of moderate speed. After examining several small boats, both side-wheel and screw propelled, it was concluded to make the boats of the "stern wheel" type; and the experience gained with these boats shows, I think, quite conclusively that this is the best type for small steamers of very light draught. The dimensions are as follows:

Length from stem to transom, 34 feet; depth of hull (midships) flat bottom, 2 feet; beam at gunwale, 7 feet 10 inches; beam at bottom, 5 feet 10 inches; height at stem, 3 feet 7 inches; height at transom, 2 feet 9 inches; boiler, vertical, 30 inches in diameter, 5 feet high, with 66 2-inch flues ¼ inch apart; firebox 22 inches high, 26 inches diameter; engines 4½ inches diamteer, 16 inch stroke; wheel 6 feet diameter, with 12 buckets 5 feet 2 inches long. The boats are steered with small steering wheels on the open half deck forward of the cabin. The boilers were tested to 225 pounds per square inch, but were rarely allowed to carry more than 120 pounds.

The draught of the boats, light, was about 9 inches. One that ran 13 measured miles down stream in one hour with a current assisting her of about 2 miles per hour, thus made about 10 miles per hour generally through the water under favorable circumstances, when the steam was kept up to 120 pounds.

Some trouble was experienced with the boiler tubes, which ran through the steam space from the flue sheet of the firebox to the upper end of the boiler. Careless firing, and the inexperience of some of the engineers, caused them to leak, but when the engineers had learned to take care of them very little trouble was experienced. They made plenty of steam, there being a strong draught from the exhaust into the smoke stack.

I think any one intending to build a very light draught launch will do well to make it a stern-wheeler, as it is much more handy than a side wheel boat and easier to construct. Of course these boats are not fit for rough water, but stood the waves of the Mississippi very satisfactorily. A foot more beam would perhaps make a better working boat and reduce the draught considerably, but 6 feet is not too narrow if good speed is wanted.   ENGINEER.

LIGHT DRAUGHT, FAST, STERN WHEEL STEAM YACHT.—DESIGNED UNDER DIRECTION OF U. S. ENGINEER OFFICER, ROCK ISLAND, ILL.
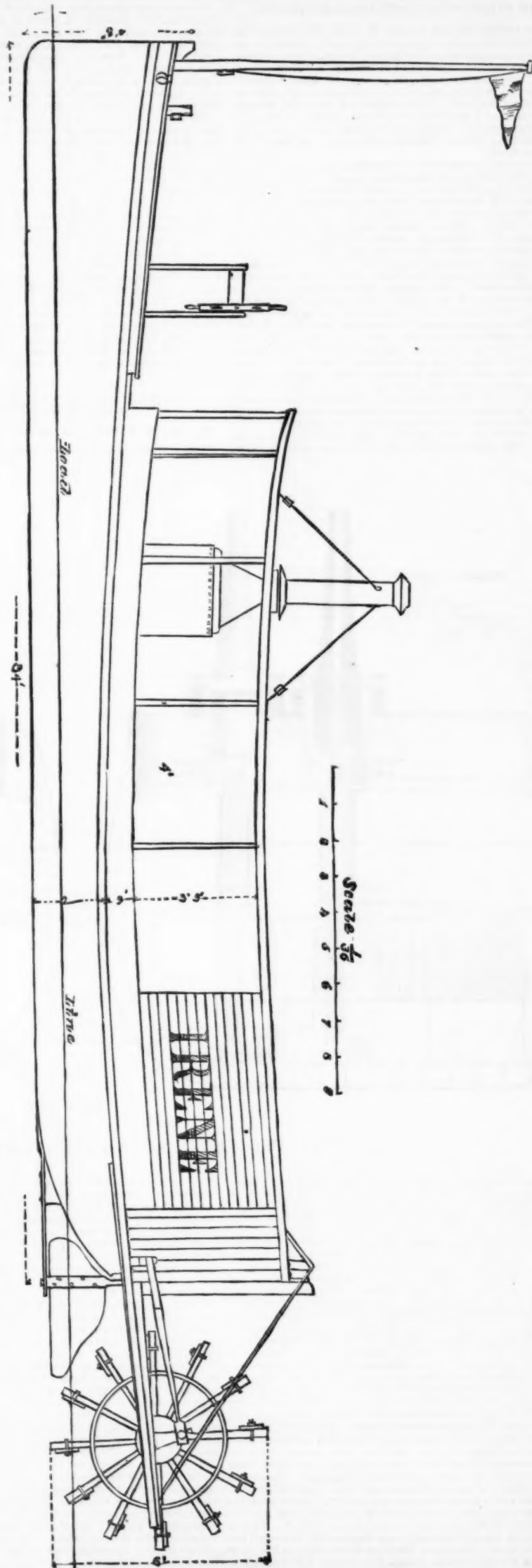
THE STERN WHEEL STEAMER MONTANA.

FEBRUARY 22, the new steamer Montana will leave on her initial trip to St. Louis, to return to this port in time for the opening of navigation on the Upper Missouri River, in April, which will be her future field of usefulness. These far-off regions, over four thousand miles from the head waters of the Ohio, so recently opened to civilization, and still the haunt, if not the homes, of the native red man, will, through the Montana and her sister vessel, the Dakota, be supplied with better means of transportation than is now enjoyed by those dwelling by the "Waters of Babylon," and the site of Paradise itself.

It is this fact, so significant in itself, which made us feel proud of the skill of our steamboat men and the intelligence of Pittsburg boatbuilders as we paced the snowy deck of the Montana. All the science, enterprise, and wealth of Great Britain has never been able to construct a steamer like the ones mentioned. If our readers doubt the statement, let them turn to "Through Asiatic Turkey," by Grattan Geary, recently republished by Harpers. It is a very interesting account of a journey made just a year ago from Bombay up the Persian Gulf, the Tigris, and thence overland to the Mediterranean. The author devotes some space to the steam navigation of the Tigris, and expresses his surprise that only nine steamers are employed as yet on that ancient river. One of these steamers is described, the Blosse Lynch, yielding a profit of 25 per cent. per annum, and as the matter is of interest, we quote the description: "The Blosse Lynch is the largest boat on the Tigris, and is made somewhat on the model of the American river steamers, with a very spacious upper deck, high above the main deck, somewhat like the first floor of a house. This upper deck is forty-five feet in breadth at the paddle boxes—an immense width, exceeded by a few of the large ocean-going steamers. The cabins below are very spacious, and there is a handsome saloon. The great width of beam has enabled the builders

Now compare these facts with the Montana and her trade. This steamer's draught of water is now, with 200 tons of freight on board, only two feet; with 600 tons she will require less than four feet. Her width is 40 feet and her length 250 feet. Where our boatbuilders excel is in the cost. The Montana cost less than half what was expended on the Tigris. The construction of the hull of the Pittsburg built boat combines lightness with strength. Our marine constructors have brought the stern wheel system to perfection—reducing the weight of the propelling apparatus to less than half, and placing it where it will do most good. The Montana has four rudders, two of them balanced, that is to say, hinged in the middle, thus affording powerful and instantly acting steering gear. Another Western idea, the sparring apparatus, worked by steam, is evidently unknown to English constructors. By this means boats can be lifted to half their length when aground, or in trying to get over shoals, and it forms an appendage perhaps the most striking and impressive of anything found on Western boats.

Of course we cannot go into other details of boatbuilding, but we have said enough, we think, to show the superiority of the Pittsburg boat over the one supplied by the best known English engineers. And it explains, too, the fact that our system of river transportation is the cheapest in the world. The rates the Montana obtains for freight will elucidate that—25 cents per hundredweight for glass, and 12½ cents per hundred for nails, to St. Louis, a distance of 1,200 miles from the point of shipping. Coal is shipped by our coal operators to New Orleans, distance 2,000 miles, for about one dollar a ton.—*Pittsburg Chronicle.*

### ON THE LOADING OF MONSTER GUNS IN MODERN IRONCLADS.*

By Capt. A. ALBINI, Post Captain, Italian Royal Navy.

THE system I have contrived may be described in general

terms to consist in loading the gun in a vertical position, the apparatus for working a sponge and rammer being dispensed with, and the latter being replaced by a hoist which raises the charge direct from the magazine. The idea is so simple that this concise statement, and an examination of the annexed drawings, render any further description almost unnecessary; but as the drawings are on too small a scale to show several essential details, I will endeavor to describe as briefly as possible the action of the mechanism, referring to the letters on the plates.

The carriage consists of two solid armor plates forming the cheeks, and bound together by a transverse armor plate at the front. The cheeks rest on two strong box beams, which contain the hydraulic recoil presses, the piston rods of which are attached to the lower part of the cheeks of the carriage. The gun mounted on this carriage has no preponderance, and can revolve on its trunnions so far as to assume the vertical position, there being no obstruction to this movement between the cheeks of the carriage. The elevating apparatus, which has a movement sufficiently extended to turn the gun to a vertical position, consists either of worm-wheel gear on both sides, or of levers carrying toothed sectors, and worked by hydraulic presses, if hydraulic power is preferred. The gun has nothing at the rear but the simple breech screw of the French system, without any mechanism attached to bind it to the breech itself, from which it is detached every time the gun is loaded, descending into the magazine to take its part in the lifting of the charge. Underneath the turret is fixed to the ship a tube communicating direct with the magazine. This tube has an internal diameter slightly exceeding that of the breech screw, and is

provided at the top with two strong pulleys, over which pass two steel wire ropes. The ropes are attached at one end to a short cylindrical piston, and at the other to a steam or hand winch. The apparatus thus performs the office of shot lift and rammer. The tube has a door in it, giving access to the magazine for putting in the charge. For convenience and simplicity, the charge is kept in the magazine ready suspended to the shot.

The loading takes place as follows: The round having been fired, after the gun is run out automatically it is placed vertically, so that its axis is in line with the axis of the lift tube. The lift piston, A, Fig. 1, being then at the top of the lift, is almost in contact with the rear face of the breech screw. By means of the movable lever, B, a quarter turn is then given to the breech screw, which descends and rests on the top of the lift piston, A. The lever, B, being taken away, and the winch set in motion, the lift then descends, bearing the screw to the bottom, where its upper surface is level with the magazine floor. If it is necessary to sponge, this operation is performed during the descent of the lift by means of brushes, by which the bore can be cleaned as well as by more complicated arrangements. In the meantime, in the magazine the charge and projectile are transported by means of runners to the tube, and placed there vertically upon the breech screw. The door of the tube being shut the lift is set in motion again until the charge and the breech screw below it reach their places in the gun. The lever, B, is then again employed to give the screw a quarter turn, by which means it is fixed, and the gun is closed and ready to be put into firing position.

To prevent the cartridge being compressed by the weight of the projectile resting on it, it is traversed longitudinally by a central bar of iron terminating in cross bars placed radially. If it be preferred not to load both simultaneously, the projectile may be lifted alone into the gun and kept in its place by a little screw bolt fixed like a vent bush, and so as to make it project into the bore or not, as required, by

TRANSVERSE SECTION A.B　　　　　FIG.1　　　　　　　　　TRANSVERSE SECTION　　　　FIG.2
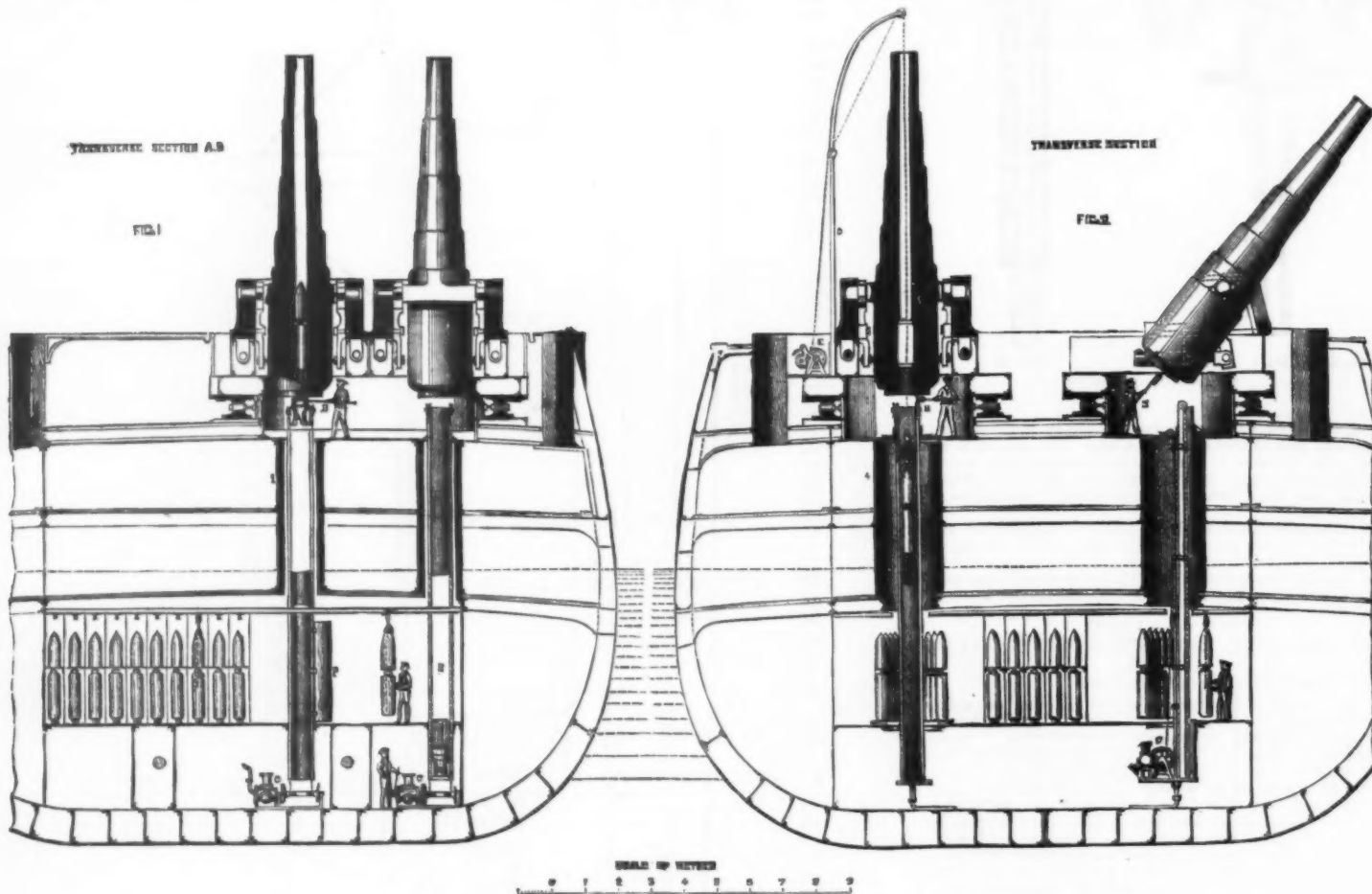
ALBINI'S PROPOSED APPARATUS FOR WORKING MONSTER GUNS.

to reduce the draught of water to four and a half feet. There is a room on board for 300 tons of cargo and a thousand passengers—of course deck passengers for the most part.

"The tedious voyage up the river, five hundred miles against the stream, lasts three days, and sometimes even eight days, according to the season; the current runs down at the rate of five miles an hour. When the river is low, and the nights dark, it is impossible to steam by night at all, or to go fast even by day. But when there is plenty of water the Blosse Lynch goes at the rate of fifteen miles an hour, if the current is not very strong. The voyage from Bagdad to Bussorah occupies on an average two days, the rapid current bringing the steamer down at great speed. The rates charged pay the company very well. It costs about as much to send goods from Bussorah to Bagdad as to get them from London to Bussorah. First class passengers are charged six pounds without food; deck passengers, fifteen shillings.

"The Blosse Lynch was ordered of Messrs. Rennie & Co., of London, and was designed on a somewhat ambitious scale for a river so capricious as the Tigris. Steel and cast iron are used throughout to combine strength with lightness. She cost £22,000 before she was put together at Maagil, near Bussorah, and the putting together took several thousand pounds more. She is a fine vessel, and has great speed when there is plenty of water in the river to float her. But when the Tigris is low it is difficult to get her through the shallows, her cargo has to be taken out and put on the bank till she floats over; she is then reloaded and goes along into the next reach, where the same operation is repeated. That is the penalty she pays for her great length—240 feet—and her width of beam. However, the river is not often so low as to occasion all this trouble, though it is always low enough to render very careful navigation necessary."

means of a handle outside. In the event of derangement by shot striking, or any other mischance, a method of loading no less convenient than the first may be substituted. This method, shown in Fig. 2, consists in suspending in the magazine, and introducing into the gun, the shot, charge, and screw, all bound together. The suspension would be by a wire rope passing over a pulley of the crane, D, situated on the carriage, and falling within the gun until it can be attached to the shot tongs in the magazine. The other extremity would be made fast to the winch. The charge being brought into place is made fast as before by a turn of the lever, B; the cord is slackened to cause the shot tongs to let go, the rope withdrawn, and the gun is ready for putting into firing position.

The following are the advantages of the above described system: (1) Economy of armor surface, because the gun being placed vertically not only for loading, but also to pass from one broadside to the other, the turrets may be placed almost touching one another, and, therefore, the armored inclosure may be reduced to smaller dimensions than those required for muzzle loaders upon the existing system, where much space is wanted to allow the projecting chases of the guns to pass as well as for the loading gear. (2) Abolition of the rammer and apparatus belonging to it, with a corresponding diminution of risk of disablement in action and economy of weight. (3) Abolition of all projections on the breech of the gun, the apparatus for working the breech screws being dispensed with; consequently less risk of derangement from being struck by fragments. (4) The charge hoist, which acts also as a rammer, has no complication of mechanism, and is generally of a character suited to sailors. It is less susceptible of derangement, and when damaged can be readily repaired with the means on board. (5) The in-

convenience complained of with existing breech loaders in turrets, viz., that the smoke fills the turret when the breech is opened, is avoided, because when the gun is vertical the smoke rises rapidly in accordance with natural laws. (6) Greater facility for arranging isolated guns by distributing them over the length of the ship, because as they may be set upright for loading and for revolving, the turrets may be placed where obstacles belonging to the other "organs" of the ship would stand in the way of every other system. And this will become a very striking advantage when the importance is recognized of distributing the guns over a more

ing, assuming the adoption of a system similar to that which I have put forward; but if the principle initiated in the Italia, of to a great extent abandoning armor, were to receive still wider application; if, as some believe, more entire dependence may be placed upon unprotected guns with protected loading gear; or if the unquestioned ability of our naval architects were to be directed to taking advantage of the value of coal as a means of defense, then ships of war might again undergo transformations of a nature to command a preference for muzzle-loading artillery. It is outside my subject to discuss here what might be the nature of such

There is nothing more dangerous for one who has to decide such arduous questions than to become infatuated with one definite system, to let himself be carried away by attractive schemes, or to yield too easily to the alarm produced by catastrophe. Only a calm, severe, and dispassionate examination of the conditions and circumstances, a timely abandonment of old prejudices, and a due appreciation of new discoveries, can conduce to a solution which satisfies, as little imperfectly as possible, the special requirements of the ship. Fig. 3 shows the arrangement for turning the gun over, which will be understood without description, and Fig. 4 is a plan of a barbette turret of the Italia and Lepanto.
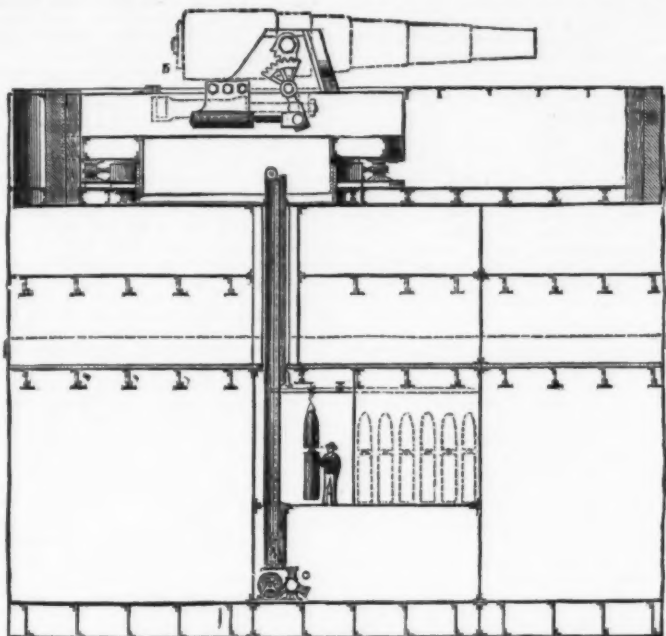

FIG. 3.—ALBINI'S PROPOSED METHOD OF LOADING MONSTER GUNS.

extended front and avoiding pairing them, as well to diminish the risk of their being struck as to remove the danger of having the whole armament paralyzed by a shell entering the battery. Such risks are doubtless increased by the development of the principle already partly forced on us of renouncing complete protection for the guns, and it is evident the stern necessity of limiting the extent of armor can only be compensated by the multiplication of independent and isolated guns. (7) The system of isolated guns loaded vertically might lead to very important economy of weight through the extreme reduction of the armor, which might be effected if a bolder step in the reform of the gun carriages were taken and the guns mounted on automatic carriages, such as those I have devised for the 7·5 centimeter and 12 centimeter guns, but with a less sharp inclination of the supporting arms, which might be placed nearly vertical, with the recoil presses behind, almost in the line of recoil, and the recoil limited to about 1 meter.

transformations. To have faintly indicated them only is enough to strengthen the assertion that among the phases which the structure of war ships incessantly and at short intervals undergoes, it is impossible to follow a type of heavy artillery invariable in general character, but the special conditions of the guns and of their arrangement and appurtenances can only be determined by the final result of the study, as a whole, of each new ship. In this study, advantage or disadvantage, considered from the point of view of the ship as a whole, is a very different matter to that inferred from an isolated comparison of gun and gun. The one is a question of differences, so to speak, inappreciable; the other may mean millions, if, for instance, two hundred tons weight more or less can be credited to the engines in the hull. When the decision is influenced by considerations of such importance, what signifies the question of a superiority of details much disputed, and at the best leading to nothing? I, indeed, am unable to give so much importance to the host of minor con-

HEAVY ORDNANCE.

At a recent meeting of the Institution of Civil Engineers the paper read was on "The Construction of Heavy Ordnance," by Mr. J. A. Longridge, M. Inst. C. E.

Nineteen years ago the same subject had been brought before the Institution by the author. In the present communication he proposed to examine the progress since made in gun construction at Woolwich, and especially referred to the official "Treatise on the Construction of Ordnance," printed by order of the Secretary of State for War, in 1877. After pointing out that, in this treatise, it was admitted that the true law of the distribution of tension was unknown to the Woolwich constructors, the author showed that the system adopted by them, and known as the Fraser system, was not based on scientific principles, and led to results both costly and unreliable. The true law connecting the pressures with the tensions was then demonstrated, first, in a homogeneous gun, and secondly, in a gun built up on the model of the 9 in. Woolwich gun (Mark III.), consisting of a steel tube and a thick iron jacket. It was shown by detailed calculations that, assuming an internal pressure of 24 tons per square inch, the inner surface of the iron jacket would be strained to about 17 tons per square inch, or 7 tons above the elastic limit of the material. This was with a shrinkage of one-thousandth of the diameter. A table was next given of the tensions of the iron jacket and steel tube due to an alteration in the shrinkage; and in another table the author showed the variation caused by a change in the moduli of elasticity of the material. Assuming a shrinkage of one-thousandth of the diameter, and moduli of elasticity of 12,700 tons for iron, and of 13,330 tons for steel, the result of repeated firing on the 9 in. Woolwich gun was investigated, from which it appeared that the effect was gradually to reduce the tensions of the iron jacket, and increase those of the steel tube, until finally the shrinkage was reduced to zero, and the gun became nearly a homogeneous gun. Under these circumstances it was shown that, while the whole bursting strain to be resisted, with an internal pressure of 24 tons per square inch, amounted to 108 tons per side, the steel tube of $3\frac{5}{8}$ in. thick supported 52 tons, and the iron jacket of 12 in. thick only 56 tons. Also, that the steel tube was strained to 27 tons per square inch at the inner surface, or 12 tons beyond its elastic limit. As a consequence, permanent set took place, increasing with each successive firing, and finally the gun failed by the cracking of the steel tube. A similar investigation respecting the 81-ton gun showed that a like result would ensue.

The author next gave the dimensions of a gun, built according to the true law, of the same caliber as the 81-ton gun, and showed that in it no portion of the material could ever be strained beyond 10 tons per square inch, with an internal pressure of 24 tons per square inch. After a few remarks on the combination of the longitudinal strain with the circumferential strain during explosion, the author described various types of heavy guns proposed to be built on the system advocated by him in 1860. Those types were—first, a muzzle loading gun of 20 in. caliber, weighing 150 tons, recoiling on its carriage; this gun would be 30 ft. long in the chase, and would throw a solid shot of 3,000 lbs. with a muzzle velocity of 1,600 ft. per second. Secondly, a muzzle loading 13 in. gun, mounted on an ordinary gun carriage. Thirdly, a breech loading 13 in. gun, weighing about $45\frac{1}{2}$ tons.

In conclusion, the author pointed out the great difference in cost between guns thus constructed and the Woolwich guns. In the Blue Book, entitled "Army Manufactory Establishments," printed on the 8th of April, 1878, the cost at Woolwich was given as follows :—

10 in. guns of 18 tons	....................£74 per ton.
11 in. " 25 tons	.................£80 "
$12\frac{1}{2}$ in. " 38 tons	..................£90 "

At the same rate of increase a 150-ton gun would not cost less than £180 per ton. By the author's system, the cost of a 150-ton gun would not exceed £35 per ton; a 13 in. muzzle loading gun, £32 per ton; and a 13 in. breech-loading gun, £50 per ton.

THE ST. GOTHARD TUNNEL.

At a recent meeting of the Engineers' Club, of Pennsylvania, Mr. Coleman Sellers, Jr., read the following extracts from a private letter written from Geneva : . . . "I went over the St. Gothard Railway with the engineer, as far as the big tunnel, to see the most difficult railway works ever attempted in the world; nearly one third of the whole line is in tunnels. In some places the railway is put in tunnels to get it out of the reach of avalanches; in one case the
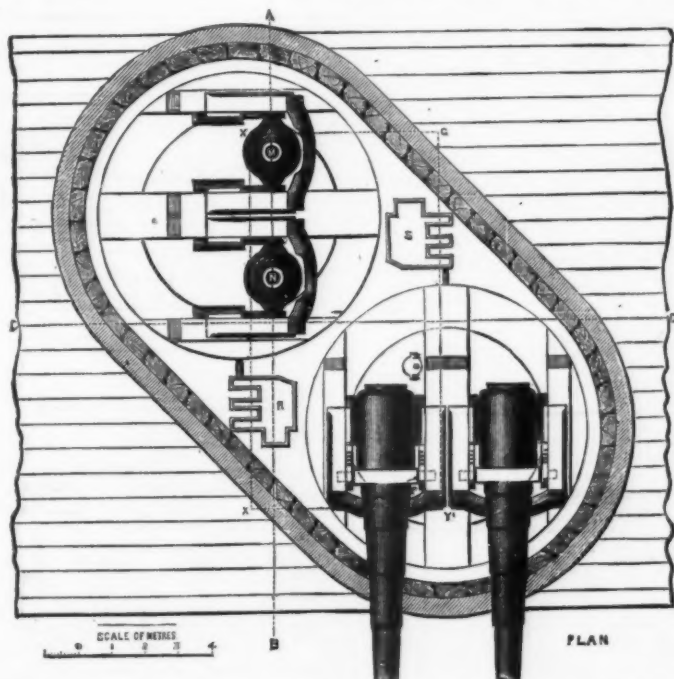

FIG. 4.—BARBETTE TURRETS OF THE ROYAL ITALIAN IRONCLADS, LEPANTO AND ITALIA.

In spite of the evident advantages of breech loading on the system described for guns in turrets, it cannot be affirmed in the abstract that loading at the breech is more convenient than loading at the muzzle. This could never be laid down for the navy as a general rule, and the decision of the artillerist alone does not suffice. The concurrence of the naval engineer is indispensable to a definite conclusion, because, as we have before said, the fitness of the one or the other system depends entirely upon the very numerous requirements of a modern ship of war; requirements which, with the alternate progress of inventions, will always be opposed to one another, so that a solution can never be reached except by way of compromise. For the types of ships of the moment the turn of things is favorable to breech load-

siderations commonly discussed as to make them outweigh all others. No kind of artillery can ever be so exempt from occasional accidents as to command an absolute superiority in that respect. Breech loading may very well escape the inconveniences and risks of muzzle loading, but it leads to others of a different nature; and who can positively say if those it escapes are, as a whole, greater or more injurious than those to which it advances? The results of actual naval combat can alone place us in a position to give an authoritative verdict, but it will be difficult beforehand to relinquish the doubt if the great weapon which presents two vital extremities to the enemy is not more liable to be rendered useless than that which possesses only one.

engineer pointed out to me, as we were riding on the highway, 60 to 70 feet above the river, the place where an avalanche came down last summer, filling the whole valley and coming up into the road where our carriage was. I will inclose to you a sketch of a piece of the location of this railway taken from their map. Their fixed maximum gradient is 1 in 40; their fixed maximum radius of curvature is 1000 meters. There are no side valleys to run up and back again to get distance, and as the valley in some places rises faster than the fixed gradient allows, the engineers are forced to tunnel into the sides of the mountains in entire circles (corkscrew circles) to get distance. The sketch I inclose shows three of these circular tunnels about eight kilos north of the big tunnel.

"The waved lines show water-courses, G G being the river Reuss. The full lines show the location of the railway lines, and the dotted lines the tunnel. The points A, B and C show bridges over a cascade. The bridge at B is about 500 feet above the bridge at A, and the bridge at C is about 300 feet above that at B. The circles in the tunnels are 2000 meters, or 6502 feet diameter.

"On the south or the Italian side of the big tunnel are more difficult locations still. The roads here are beautiful, built and kept in order by the state.

"The tunnels of this railway (even the big tunnel is solid granite, and wide enough for three tracks) are arched with granite, but little inferior to the face work of the Astor House. None but the rich nations of Europe could, for a moment, think of building such a railway.

"I was run into the big tunnel for two kilos, on one of their air engines, to see a drilling machine I once explained to you. Baron Lauber tells me it is pressed against the rock with a pressure of 130 atmospheres, and that it walks into granite, as if it was cheese."

* * * In regard to the abundance of water-power in Switzerland, Mr. Evans says: "There is a tremendous water-power going to waste all over Switzerland; you can see in hundreds of places streams of water coming down nearly perpendicular for 1000 or 2000 feet. At the great tunnel of the St. Gothard Railway the river Reuss crosses the very mouth of the tunnel, and gives the engineers a water-power fifty times greater than they can use for compressing air, making repairs, etc, etc."

THE ST. GOTHARD TUNNEL.

IN a paper just communicated to the French Academy, M. Colladon gives some interesting details of the progress of this great enterprise. Besides the excessive hardness of the banks of serpentine and quartz, and the insufficiency of hydraulic forces on the Airolo side (after the lowness of water in winter), there has been a very troublesome infiltration in the south portion, the volume of water having increased since the second year to more than 235 liters (70 gallons) per second in the advance gallery. The difficulty of working here under jets, which had often the force of those from a fire-engine pump, can be readily imagined. Another difficulty arises from a mass of decomposed feldspar mixed with gypsum, found under the plains of Audermatt. This plastic material swells on contact with moist air, and exerts a pressure of terrible force, capable of crushing the strongest woodwork, and even arches of granite. In some of these parts the workers thought themselves happy when they were able to advance (with manual boring) about 1 meter in three or four days; whereas, through granite, with compressed air and mechanical perforation, a regular advance of 4 meters in 24 hours has been achieved; through gneiss, 6 metres, and more. As regards apparatus, M. Colladon states that the volume of water from the Tremola (Airolo side) having been found insufficient, M. Favre brought water in an aqueduct, 3000 meters long, from the Tessin, to work new turbines and four compressors, on the same system as the others, but of greater volume. These turbines are of cast iron. It is noticeable that the old and smaller bronze turbines (formed of one piece), which have made some 155,000,000 revolutions per annum, are in good preservation after four, or even five years' service, and still work usefully, after slight renewals. On each side of the tunnel there are at present sixteen air compressors in action, serving both for aeration and for boring operations. They send into the tunnel air under a pressure of eight atmospheres, sufficient to drive eighteen to twenty drills, and effect good ventilation of the part already bored, which is at present 6100 meters on the north side, and 5390 meters on the south side. On either side there are, night and day, several hundreds of workmen with lamps, and about 300 kilogrammes of dynamite are consumed. The compressors are found to suffice for good ventilation, rendering unnecessary two large exhaust vessels, placed two years ago at either mouth of the tunnel for drawing off smoke and vitiated air. The transport of materials is effected by horses in the more advanced part of the tunnel, and by compressed air locomotives in the portions near the mouths. To feed these locomotives eight of M. Colladon's compressors are placed at Airolo and Goeschenen. They draw air from the ventilating pipe, and force it, under a pressure of 12 or 14 atmospheres, into a pipe which passes along the part traversed by the locomotives. A great variety of rock drills has been used. Each year brings new improvements.

FIREBRICK FIRE BOXES FOR LOCOMOTIVE BOILERS.

WE have received from Mr. Verderber, the inspector-in-chief of the Hungarian State Railways, some very interesting particulars of the results he has obtained with a new construction of locomotive boiler of which we now publish illustrations. The peculiar feature in this boiler is that the heating surface of the firebox is dispensed with, there being employed, in place of the ordinary firebox, a combustion chamber lined with fireproof material. The account of the experiments which led to the adoption of this system of construction can best be given in Mr. Verderber's own words as follows:

On most lines of the Hungarian government railways the feed water is very bad, and forms large quantities of sediment; consequently the boilers of this company need more frequent and extensive repairs, particularly on their fire-boxes, than those of other companies having at their disposal a better kind of feed water. Under these circumstances I endeavored, as many other engineers have done before, to remove or at least to lessen, this inconvenience caused by the failure of fireboxes. Examining the investigations of others, I became convinced that only by abolishing the water-surrounded fireboxes would there be a possibility of effecting a real remedy, and in consequence I tried to solve this problem, and contemplated the employment of a cylindrical tubular boiler combined with a fore-fire of fireproof material for receiving the firegrate.

The fact that the firebox, with a moderate application of the blast pipe, produces nearly fifty per cent of the whole steam produced by the boiler, has led to the false notion that the cylindrical part of the boiler is not capable of producing the necessary quantity of steam without the aid of the firebox. My observations, however, led me to another conclusion. It first struck me why the heating surface of the tubular boiler performs so little work in comparison with the firebox. The reasons for the small capability of the boiler tubes in comparison with the firebox are the following:

1. The burning gases pass only through a part of the tubes, consequently the other part is either quite or partly out of action.

2. The temperature of the burning gases diminishes during their progressive movement in the tubes, and therefore less heat will enter the boiler toward the smokebox end.

3. Finally, and principally, the deficient heating capability of the boiler tubes is accounted for by the fact that nearly 50 per cent of the available heat is absorbed by the firebox before the burning gases enter the boiler tubes, in consequence of which they cannot possibly take up more heat.

There is no reason at all why the tubes should—at equal temperature and density of the burning gases—evaporate less water per square foot of surface than the firebox; I had, therefore, no doubt whatever that if the burning gases at their original temperature could be led into the boiler tubes, they would receive the whole available heat, and consequently the tubular boiler would do as much work without the firebox as with it, that is to say, the firebox as a steam generating part of the boiler is superfluous.

Although the minute examination of the results of the interesting experiments carried out by the French Chemin de Fer du Nord regarding the evaporative capability of locomotive boilers, published by M. Ch. Couche in his work, "Matériel Roulant et Exploitation Technique des Chemins de Fer," vol. iii., led me to the same conclusion, I hesitated to reconstruct a locomotive engine before my notion was proved by an experiment to be correct. I therefore isolated the firebox from the boiler of a locomotive by fitting to it plates covered with fireclay. Figs. 1 and 2, below, show how the isolation was carried out. The plates were placed at a distance of 60 to 70 mm. from the copper firebox, and the intervening space was divided into two parts by means of a diaphragm, a b. The cold air entered through the conical opening, c, into the space, and was led from there under the grate. The temperature in the space between the firebox and the fireclay covered plate was 300 deg. to 350 deg. Cels. (572 deg. to 662 deg. Fahr.), while the locomotive stood still, and 70 deg. to 90 deg. Cels. (158 deg. to 194 deg. Fahr.) while running, according to the speed, upon which the draught depended. The locomotive, working with a pressure of 8½ atmospheres, the temperature in the space was, during work, about half of that of the copper firebox sides, therefore not only was no heat given up to the boiler by the firebox during work, but the firebox even lost a part of its heat to the entering air.

The locomotive fitted out with this isolating plate-wall was a passenger engine, which took the trains between Budapest and Miskolcz ten weeks running. The result was found to be that 1 kilo of coal evaporated the same quantity of water as before putting in the plate. Now, after the locomotive had been in service through ten successive weeks, the isolating plate-walls inside the sides and crown of the firebox were taken out, and upon the same line, with equal speeds and weights, the observations were continued, the result showing the same effect as regards the heating power of the coal. By means of these simple experiments it was clearly shown that, with the present dimensions of the cylindrical part of the locomotive boiler, the firebox as a steam-creating part can easily be dispensed with. If, therefore, some engineers pretend to have, or really should have, gained favorable results by enlarging the direct heating surfaces, that is the firebox sides, then the increased capability of the boiler thus gained is not to be accounted for by the larger firebox surface, but probably by the enlarging of the firegrate, as, in consequence of this, larger quantities of coal have been consumed.

The experiment with the isolating plate-walls also gave information as to the durability of the fireproof material in the firebox. It was noticed that this material, if cooled from the outside—as was the case with the isolating walls—was not at all altered by the influence of the fire.

The dispensability of the firebox as a steam generating part of the boiler, and the durability of the fireproof material, having been clearly shown by the experiments with the isolating walls, the reconstruction of a locomotive was decided upon, and for this purpose our goods train locomotive, No. 39, was chosen, this engine having three coupled axles and 36 tons adhesion weight, and its copper firebox being defective and requiring renewal. The reconstruction was

Fig. 1.　　Fig. 2.　　Fig. 5.　　Fig. 6.

Fig. 3.　　Fig. 4.

Fig. 7.
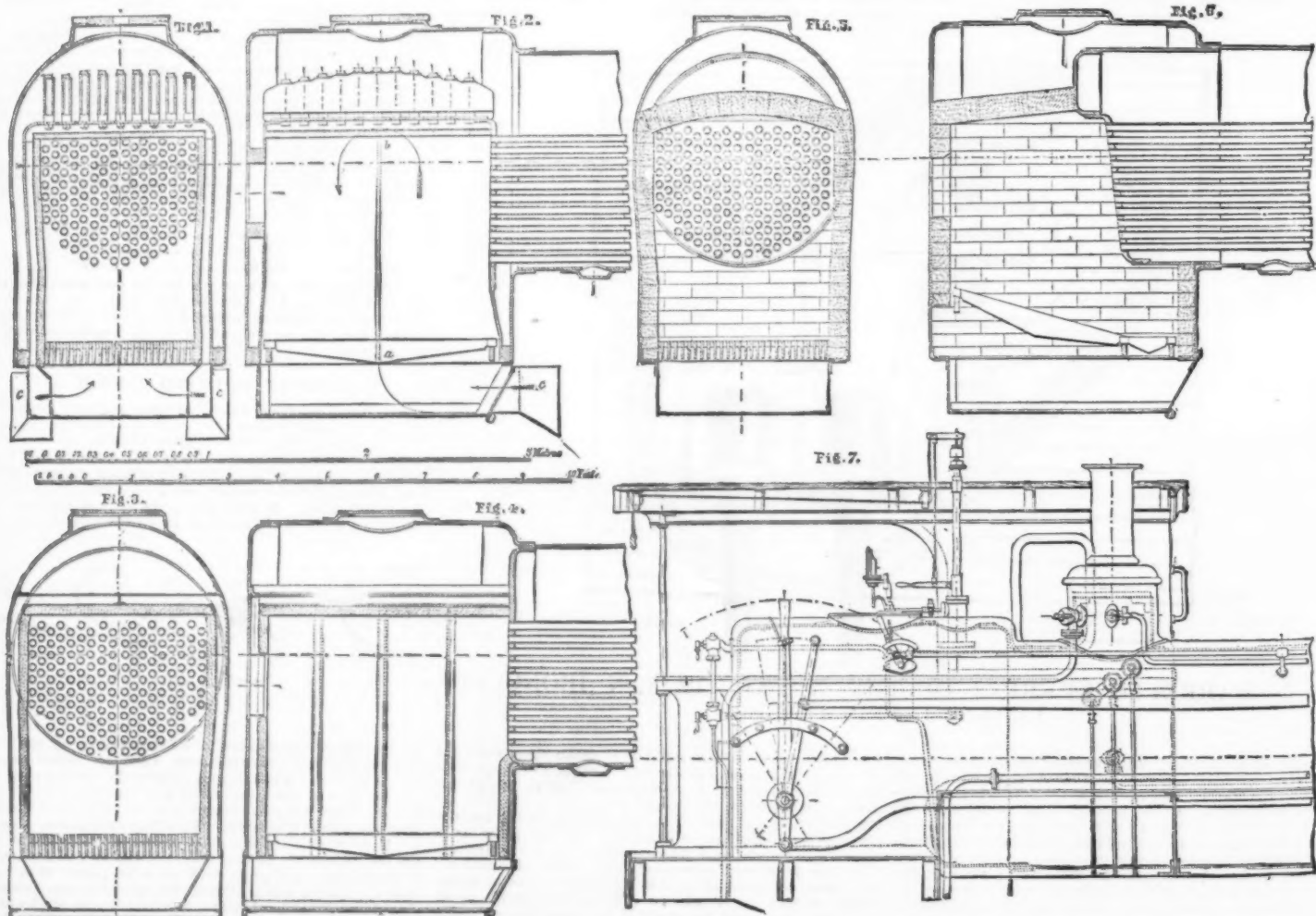
VERDERBER'S LOCOMOTIVE BOILERS, WITH FIREBRICK FIRE BOXES.

carried out as shown in Figs. 3 and 4. The tube-plate was put on the end of the cylindrical boiler, so that the tubes remained of their original length; a casing of 9 mm. plate was pushed into the outer firebox casing for receiving the grate. The inner sides of this casing were covered with 30 mm. to 40 mm. (1·2 to 1·6 in.) of fireclay (chamotte), which was fastened to the plate by small riveted hooks. The positions of the glass gauge, gauge cocks, whistle, etc., had to be accommodated to the construction.

After the so reconstructed locomotive had done station service a few days without any complaint, a trial trip was carried out on August 11, 1877. The train was composed of the locomotive, the tender, and 37 empty goods cars, and went with a speed of about 40 kilos (about 25 miles) per hour. The steam generation was normal, the same as with locomotives with common fireboxes.

The train went from Budapest to Isaszegh (about 17½ miles) without stopping; after the train had stopped at Isaszegh, about 10 minutes, the middle tubes began suddenly to leak, and to such a degree that the water gushing out from between the tubes, and their seats in the tube-plate, extinguished the fire. The locomotive not being able to do any more service was brought into the repairing shop. A very minute examination proved the tube-plate to be bent in an S shaped curve and about half of the tubes to be loose in their seats. As no other fault could be detected the tubes were riveted up and other trial trips were managed. During these the curve of the tube-plate remained unaltered, but the leaking of the tube seats always took place the same as at the first trial trip, after a long stoppage.

The reason for this leaking was as follows: The intervals between the tube holes of the tube-plate expanded, and as the ends of the tube-plate were not exposed to the fire, and could not expand freely, the copper tube-plate was obliged to expand against the tube ends, which caused the tube seats to become smaller in diameter, in consequence of which the tube ends were jolted. When cooling down took place the holes got into their original size, which the tube ends did not, and of course the water rushed out as soon as the cooling occurred. Although these first trials did not show that a practical arrangement had been attained for general use, they clearly showed that the firebox, as a steam-generating part, could be dispensed with, and I felt, therefore, justified in continuing with the experiments.

To avoid the faults experienced in the locomotive No. 39 during the first trials, I resolved to try the construction shown by Figs. 5 and 6. In this arrangement, as shown in Fig. 6, the cylindrical part of the tubular boiler reaches into the fire room, the tube-plate is composed of two parts, and has a play for expansion both in the vertical and horizontal direction. With this system I had our locomotive, No. 104, fitted up, this being again a goods train locomotive with three coupled axles and an adhesion weight of 36 tons. After its reconstruction it was put to regular traffic, and ever since it has performed regular service.

On purpose to obtain exact results about the performance of the locomotive No. 104, very detailed experiments were carried out, and, to get comparative results, parallel trials were made with the locomotive No. 19, of the same type, with a common firebox. An abstract of the results of these trials is shown in the annexed table. For fuel coal from the S. Tarjau mines was used, this fuel belonging to the better sort of brown coal.

4. The firebox is cased with plate, and the space of about 50 mm. (2 in.) is stuffed with slag wool, consequently the temperature of the casing-plate is much lower than that of a common locomotive. One may safely put his hand upon the casing-plate of the locomotive No. 104 while working, which one could certainly not do on other locomotives. This shows that less heat will be given up to the outside than is the case in locomotives with common fireboxes.

5. The locomotive No. 104 had at the beginning a plate-casing the same as locomotive No. 39 (Figs. 1 and 2); afterward this casing was put away, and a common firebrick lining, with arched roof, was made (Figs. 5 and 6), which has worked about five months, and wears very well. My apprehension that the brickwork would suffer by the shaking of the engine has proved unfounded. The fireclay-covered plate-casing has the advantage that steam will be sooner raised, because the coating of fireclay (chamotte) 30 to 40 mm. thick, will absorb less heat than the massive wall, but the plate-casing being more expensive, and apt to scatter down, a simple firebrick lining is by all means preferable.

For the locomotive engineer the experiments above described will be of great interest, they showing that the firebox, as a steam generator, can be dispensed with, and that the cylindrical part of the boiler is quite sufficient for this purpose; that, as for the steam generation, the ordinary dimensions of the barrel are sufficient to contain tube surface to do the work of the heating surface of the firebox if enlarged or reduced. It will also be of interest to technical men to know that the firebrick lining of the combustion chamber stands perfectly against the shaking of the locomotive as well as against the temperature of the firebox, and a fireproof fore-fire is therefore practically applicable to locomotive boilers.

It must be left to further experience to decide whether these facts have, in my system of construction, been duly made use of, and it is to be desired that further experiments should be carried out by others, as the eminent advantages of dispensing with the fireboxes are quite undeniable. The difference of the cost between renewing a single cylindrical tubular boiler and a common locomotive boiler with a copper firebox, shows clearly the advantage. The cost for replacing a new copper firebox amounts, in large locomotives, to from £250 to £300, whereas the reconstruction, according to my system, taking in calculation the value of the old copper material, does not cost quite £50.—*Engineering.*

A NEW DUPLEX SYSTEM.

By S. M. Banker.

As the method by which our duplex circuits are to be worked with as much ease and as little trouble to the telegraphist as an ordinary simplex Morse, notwithstanding the variations of our lines due to the climate, has not yet been invented, or if invented the fortunate inventor has not made it known, I have no doubt that the following method of working a duplex circuit may be interesting to many, as another solution of the problem, without putting forward the least claim to any superiority over the differential system.

It consists of a specially constructed relay and a continuity preserving key, besides the battery and Morse or sounder.

On glancing at the accompanying figure it will be seen that the relay is constructed of two coils, A B, distinct and separate from each other. One, B, is fixed to the base of relay, whilst the other, A, is movable by means of a rack and pinion R at right angles to the tongue of relay T. Each core of the coils is prolonged top and bottom by pole pieces P turned toward each other, between which the permanent magnet M moves. This magnet is of horse-shoe form, pivoted top and bottom at c with the legs between the coils, the upper leg of the magnet being lengthened, forming the tongue T for completing the local recording circuit at L and also giving a convenient point for attaching a spiral spring at s.

The key is a modification of the one originally invented by

Nystrom, in which the lever K being pressed down moves the spring G off the contact H, so that the contact between G and K is made before the contact between G and H has been broken, thereby preventing any disconnection in the circuit.
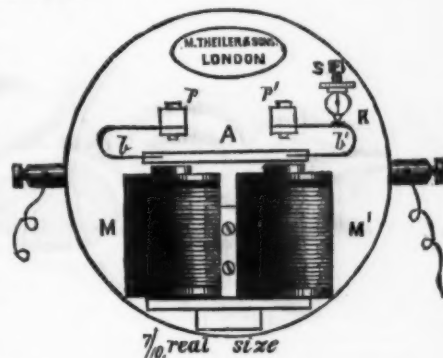
This duplex is worked by the system of the current only going through one coil of the relay at a time from the sending station, and is accomplished by joining a pole of the battery, say copper, to the contact H of key, and thence to line through the coil B in such a direction that the magnet M is attracted when the spiral spring s is loose; then the other pole, zinc, is attached to lever of key K, and so to earth through the coil A, passing round the core in the same direction as in B, producing in the electro-magnets opposite polarity and causing a pull on the magnet M always in the same direction. The spring G is joined to earth.

The stations adjust their own apparatus independently of each other, commencing by putting a piece of paper between contact H and G of key, pressing down lever K, putting current on line through B, at same time increasing the tension of spring s until it just pulls the tongue or relay off local contact L, then prove the balance by sending dots rapidly. Now remove the piece of paper from between contacts H and G, allowing the current to pass through coil A to earth, and move the coil A by means of the rack and pinion until it just moves the tongue of the relay T off the local circuit contact L. If these two operations have been performed correctly the working of the key does not affect the relay, and the relay is now in such a position that a very slight current coming from the line and traversing the coil so as to increase the magnetic effect of that coil will throw the tongue of relay over to the local contact L.

As this system compels the stations to work with assisting currents, it will be readily seen that the relay of one station responds to the movements of the key of the other station, whether the first station is sending or not. Further, the point of changing the battery from one coil to the other is so short by the arrangement of the key that it does not affect the signals.—*Telegraphic Journal.*

NEW SOUNDER.

Messrs. Theiler & Sons, London, Eng., have lately designed and are now making a very simple, but highly efficient, form of sounder, which is free from the objections which have been raised against the ordinary form of instrument. In the new pattern the dash is readily distinguished from the dot by the longer *duration* of the sound, the latter resembling a bugle note, which can be made loud or soft at will.

7/10 real size

The figure shows a plan of this extremely simple instrument.

The vibrating reed, A, consists of an iron armature attached to two flat springs, b b', which are bent into U shape (to save space), and which are firmly fixed to the pillars, p p'. The electro-magnet, M M', is planted as close as possible to the armature, A, without actually touching it. The adjustable contact, S impinges on the spring, b, at R, but breaks connection as soon as A is attracted by M M'. In order to secure the parts firmly in their place the whole is mounted on a hollow metal base, to which a bottom of thin Swiss pine is screwed, thereby increasing the sound very considerably.

A single Fuller's cell is sufficient to work this sounder satisfactorily; and Messrs. Theiler have no doubt of being able to make a sounder on the same principle which will work with the direct line current.

Theiler's sounder differs from similar acoustic apparatus in having no *free* end to the vibrating reed; the sound, therefore, starts and ceases the *very instant* the key makes and breaks contact.

We have had an opportunity of examining one of these instruments and can testify to their efficiency.—*Telegraphic Journal.*

Table showing Summary of Results as regards Coal Consumption and Water Consumption obtained from Locomotives Nos. 19 and 104.

Class.	Number.	Line of Railway.	Distance.	Average Load taken from Tables of Load.	Real Average Load.	Effect.	Coal Consumption. Total.	Per 100 tons Kilometre.	Standard Allowance of Coal for the Work.	Saving.	Distributed Premium.	Water Evaporated.	Evaporation per Kilogramme of Coal.
			kilm.	tons.	tons.	100 tons kilm.	kilo.	kilo.	kilo.	kilo.	ft. kr.	kilo.	kilo
III.	19	Budapest-S. Tarjau ...	123.4	515.0	380.0	468.9	2,471	5.27	4,149	1,678	2 68	11.55	4.67
III.	04	" " ...	123.4	521.0	352.8	435.4	2,425	5.57	3,949	1,525	2 44	11.49	4.73
III.	19	Budapest-Miskolez ...	182.6	483.0	301.8	550.0	3,960	6.11	5,493	2,133	3 41	15.41	4.59
III.	104	" " ...	182.6	483.3	292.5	534.4	3,428	6.41	5,384	1,956	3 13	15.14	4.41
III.	19	Durchschnittlich beide Linien	153.9	...	3.469	521.6	2,916	5.59	5,028	2,112	3 78	13.48	4.62
III.	104	" " "	153.0	...	3.227	493.7	2,927	5.93	4,833	1,906	3 05	13.82	4.55

Locomotive No. 104 has a cylindrical tubular boiler with grate in front, enclosed in firebrick box. Locomotive No. 19 has an ordinary firebox.

The table enables a judgment to be formed of the capability of the boiler without a firebox as a steam generating part. The summary shows that the locomotive No. 104 evaporated 4·55 kilos water per 1 kilo of coal, whereas No. 19 evaporated 4·62 kilos, that is 1½ per cent. more. This difference is so trifling that it could not be asserted whether it is to be accounted for by the construction, or else by such incidents as will occur during trials like these, and the influence of which upon the results cannot be determined.
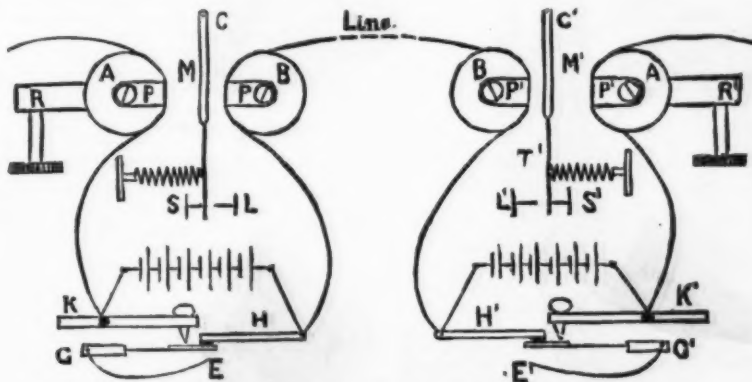
The following points have been noticed during the working of the locomotive No. 104:

1. With equal consumptions of fuel the blast pipe must be throttled closer than with the common firebox, because the burning gases in the isolated fore-fire have a much higher temperature than in the common fireboxes surrounded with water. Concluding from the quantity of water evaporated by the common firebox, the temperature in the isolated fore-fire might have been about 300 deg. to 400 deg. Cels. (540 deg. to 720 deg. Fahr.) higher; therefore the volume of the burning gases entering the boiler tubes will be 30 to 40 per cent. larger than is the case with common fireboxes.

2. The settling of the solid ingredients of the feedwater, which takes place in the common locomotive boiler at the firebox end, occurs in this case in about the hind third of the length of the tubular boiler, which shows that this part produces the steam, whereas, in common locomotive boilers, this is chiefly done by the firebox. For this reason this part of the boiler must be kept clean, and it is advisable to omit a few tubes in the lower part, and to put washing plugs instead; it has also proved very handy in practice to put a manhole into the lower part of the boiler, as shown in Figs. 2, 4, and 6.

3. The firebox being omitted the quantity of boiler water is consequently very much reduced, which causes the water level to fall more quickly during work if no proper feeding takes place. This can be prevented by an injector acting continually, and answering the average consumption of water.

IMPROVED DUPLEX TELEGRAPH.

FIG. 11.—CONIFEROUS CRYSTALS OF KRUPP SPIEGELEISEN, 200:1.

1/180 in.

1/150 i.n.

FIG. 12.—CRYSTALS WITH ADHERING GLOBULES, 75:1.
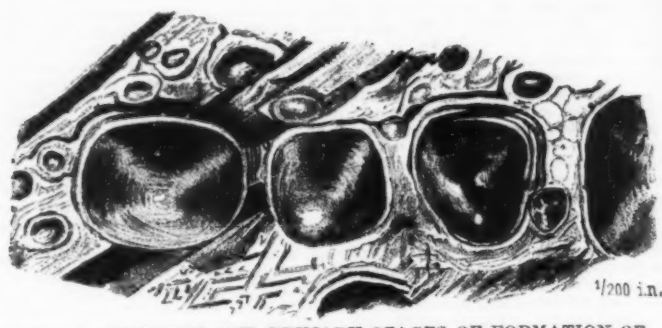

1/200 i.n.

FIG. 13—GLOBULES AND PRIMARY STAGES OF FORMATION OF CONIFEROUS CRYSTALS, 150:1.

1/70 in.

FIG. 14—GLOBULES AND PRIMARY STAGES OF FORMATION OF CONIFEROUS CRYSTALS, 70:1.

a.   b.

c.   d.
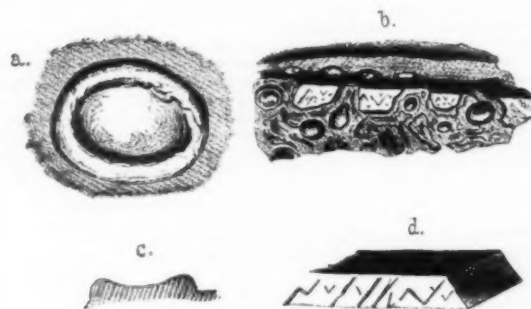
FIG. 15 a, c.—GAS BUBBLE, CONTRACTED OR FALLEN IN, 400:1.
b, d.—POSITION OF CRYSTAL, 400:1.

a.

β

α

1/400 i.n.

b.

β   α
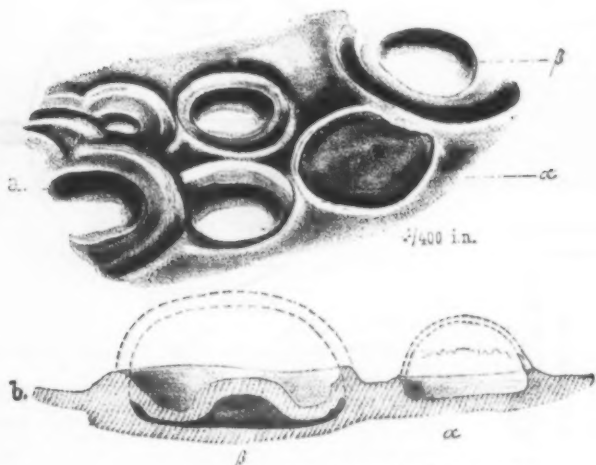
FIG. 16 a.—WARTS AND DEPRESSIONS, 400:1.
b.—VERTICAL SECTIONS OF WARTS AND DEPRESSIONS, 400:1.
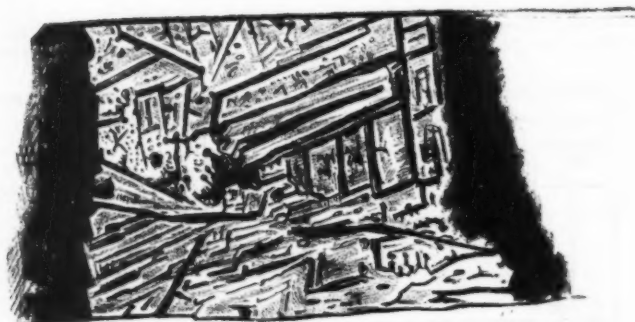
FIG. 17.—FACE OF CRYSTAL, SHOWING NATURAL ETCHED FIGURES. 200.1.

a.   b.

Schnitt ab

c.   d.
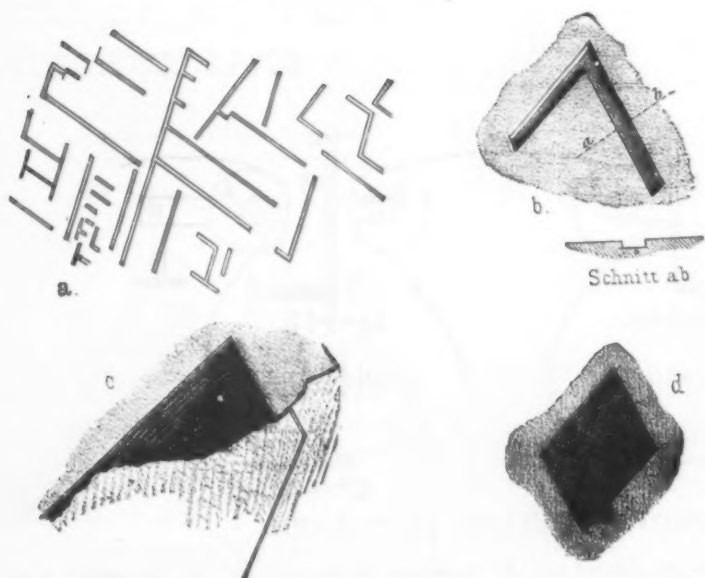
FIG. 18.—a, GENERAL DISPOSITION OF GROOVES. b, PLAN VIEW AND VERTICAL TRANSVERSE SECTION OF GROOVE. c, DEPRESSION IN CRYSTAL, SHOWING GROOVES SUPERPOSED LIKE STEPS. d, RHOMBIC CAVITY.

1/175 in.
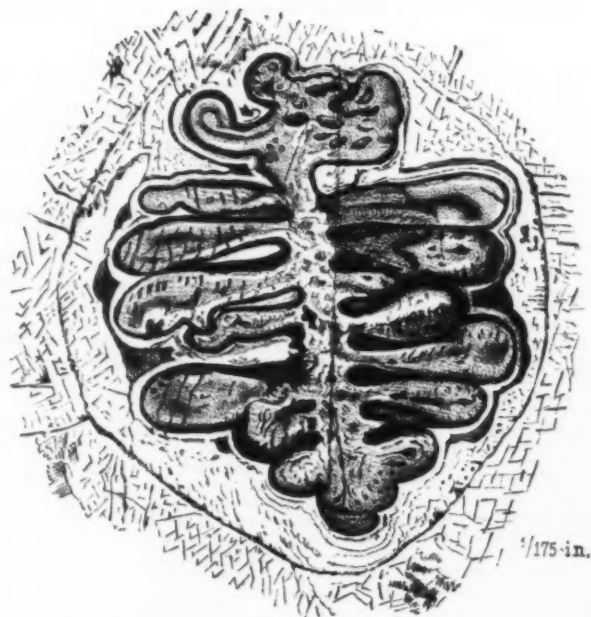
FIG. 19.—NATURAL ETCHED FIGURES IN IRON CONTAINING MAN-GANESE, 175:1.

NOTES ON THE MICROSTRUCTURE OF SPIEGELEISEN.—II.

Condensed from a Report by A. MARTENS to the Society of German Engineers.

FRACTURES.

The scales have a tendency to develop into oblong tabular crystals, as may be seen from Fig. 7 b. These again disintegrate into smaller ones, and this is probably the primary stage of the formation and accumulation of bundles of long rectangular crystals, as represented by Fig. 11. These crystals have rarely well defined edges, and hence it is difficult to measure the angles of the pointed ends, but they probably measure 60°.

To these crystals of spiegeleisen a number of globular or conical elevations are attached. They are probably of secondary origin; at least we must conclude so from the fact that they frequently inclose portions of crystals. Fig. 12 represents two elevations of this kind, in which a crystal is partially embedded.

Dürre has advanced the theory that the metallic globular masses frequently noticed in spiegeleisen consist of chemically pure iron, and I am inclined to hold the same opinion, at least in regard to a certain class of them. There are others, which, although resembling them so closely that only an experienced eye is able to discover them, indicate a different origin. Deposits of the latter character are shown in Fig. 15 a, while those represented by Figs. 11 and 12 undoubtedly belong to the former class.

These are generally found where the scales indicate a tendency to transform into rectangular, long crystals. In the same measure, as this process advances, the granules become scarcer in number, but larger in size. The originally sound masses acquire a conical shape and elongate gradually, until a certain number of them unites and forms a crystal resembling in shape the branch of a pine tree. Of these crystals I have spoken already before. The various stages of development may be seen in Figs. 11, 12, 13 and 14. Hereby Mr. Dürre's theory gains in strength, as it has already been shown that these pine tree shaped crystals, or coniferous crystals, as we call them, contain, besides pure iron, only traces of graphite. The surface of these globular deposits possesses a high degree of polish.

The second class of these globular formations, or "warts," as they have been termed by Ledebur, evidently have a different origin, as may be seen from Figs. 15 and 16. I believe them to be the results of the evolution of gas during the process of cooling and contraction. Their formation is schematically illustrated by Fig. 16. In a are shown a number of flat depressions, some of which contain elevations in their center representing the "warts" alluded to. In Fig. 16 b, a and b are vertical sections of two depressions a and b, Fig. 16 a. It is evident that both have been formed by bubbles of gas while the iron was yet in a semi-liquid state. To form a, the bubble must have burst, leaving a depression with elevated rim; in b, the bubble did not burst, but contracted on cooling, and formed the central elevation or wart.

These depressions have an average diameter of 0·019 of an inch.

The crystals shown in Fig. 11 are frequently covered with a film of oxide, which often is so thick that they cannot be recognized.

I have observed on the surfaces of these crystals figures which resemble very much those produced by the action of acids, and to distinguish them from those produced by chemical reagents, but at the same time to indicate their peculiar character, I have called them "natural etched figures." When heated, the deeper portions of the figures become darker and show various blue tints. Probably the shade of the color depends upon the thickness of the layer of oxide formed.

These figures are, on well developed crystals, formed by numerous straight lines, crossing each other in various directions, and forming angles of 90, 60, 30, and sometimes of 15° with each other. An idea of their appearance may be obtained from Figs. 15 d, 17 and 18.

The lines in reality consist of grooves, varying in width from 0·0029 to 0·0039 of an inch, and probably about just as deep.

Some kinds of spiegeleisen present peculiar figures of forms similar to those shown in Fig. 19. These generally consist of a number of loops, arranged symmetrically, and inclosed by one or more concentric rings. When heated, they acquire a greenish bronze color, on silvery white ground. They are surrounded by grooves, corresponding to those just mentioned, arranged with astonishing regularity.

These figures I have principally met with in spiegeleisen containing much manganese, and it seems as if their occurrence were directly dependent upon the amount of manganese contained in the iron. This must, however, be yet verified by further researches.

[To be continued.]

SPONTANEOUS COMBUSTION.

E. BING, of Riga, has experimented with different materials, wadding, raw flax, hemp, the waste from silk, wool, and cotton spinning as well as sponge, and finally wood dust, as found in any cabinetmaker's shop. They were saturated with various fluids, viz., oils fresh and in a gummy state, turpentine, petroleum, various varnishes, etc.

All the fibrous materials took fire when saturated with any of these oils or with mixtures of the same. Sponge and wood dust, on the contrary, proved to be entirely harmless.

Combustion ensued most rapidly with 17 g. of wadding and 67 g. of a strong oil varnish, in 34 minutes; while 200 g. of washed cotton waste, of which a portion was saturated with 750 g. of strong oil varnish and the remainder wrapped about it, required almost 14 hours. These materials were placed in a well-sheltered spot and subjected to a heat of from 18° to 40° C.

Silk did not flame up, but slowly charred. Small quantities seem to take fire sooner than large.—Wochenschrift des Ver. deutsch. Ing.

[Heretofore it has been supposed that petroleum would not cause spontaneous combustion.]

METALLIC PACKINGS.

J. STRIEDER, of Elberfeld, uses tubes of lead or some soft metallic alloy, filled with hemp, cotton, or some other suitable vegetable material. These tubes can be prepared of great length and cut to fit any given requirement. The ends may be either soldered together or forced into close contact. The convenience, durability, and cheapness of this packing are especial recommendations.—Dingler's Pol. Jour

ON A NEW CHEMICAL INDUSTRY ESTABLISHED BY M. CAMILLE VINCENT.*

"AFTER I had made the discovery of the marine acid air, which the vapor of spirit of salt may properly enough be called, it occurred to me that, by a process similar to that by which this acid air is expelled from the spirit of salt, an alkaline air might be expelled from substances containing the volatile alkali. Accordingly I procured some volatile spirit of sal ammoniac, and having put it into a thin phial and heated it with the flame of a candle, I presently found that a great quantity of vapor was discharged from it, and being received in a basin of quicksilver, it continued in the form of a transparent and permanent air, not at all condensed by cold."
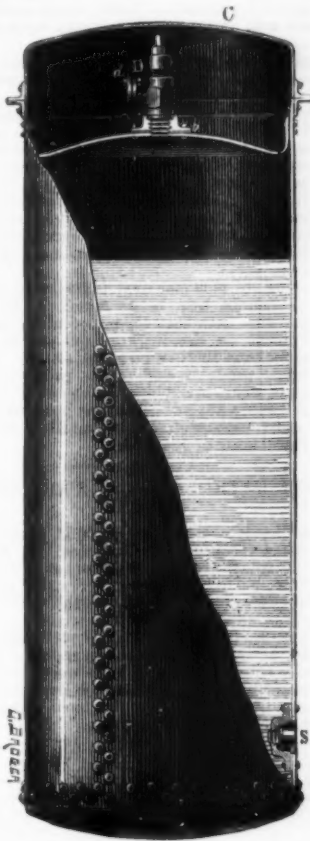

FIG 1.—RECEIVER FOR LIQUID GASES.

These words, written by Joseph Priestley rather more than 100 years ago, described the experiment by which ammonia was first obtained in the gaseous state. Unacquainted with the composition of this alkaline air, Priestley showed that it increased in volume when the electric sparks are passed through it, or when the alkaline air (ammonia) is heated, the residue consists of inflammable air (hydrogen). Berthollet, in 1788, proved that this increase in bulk is due to the decomposition of ammonia into nitrogen and hydrogen, whilst Henry and Davy ascertained that two volumes of ammonia are resolved into one volume of nitrogen and three volumes of hydrogen.

The early history of sal ammoniac and of ammonia is very obscure. The salt appears to have been brought into Europe from Asia in the seventh century, derived, possibly, from volcanic sources. An artificial mode of producing the ammoniacal salts from decomposing animal matter was soon discovered, and the early alchemists were well acquainted with the carbonate under the name of spiritus salis urinæ. In later times sal-ammoniac was obtained from Egypt, where it was prepared by collecting the sublimate obtained by burning camels' dung.

Although we are constantly surrounded by an atmosphere of nitrogen, chemists have not yet succeeded in inducing this inert element to combine readily; so that we are still dependent for our supply of combined nitrogen, whether as nitric acid or ammonia, upon the decomposition of the nitrogenous constituents of the bodies of plants and animals. This may be effected either by natural decay giving rise to the ammonia, which is always contained in the atmosphere, or by the dry distillation of the same bodies, that is, by heating them strongly out of contact with air, and it is from this source that the world derives the whole of its commercial ammonia and sal ammoniac.

Coal—the remains of an ancient vegetable world—contains about 2 per cent of nitrogen, the greater part of which is obtained in the form of ammonia when the coal undergoes the process of dry distillation. In round numbers 6,000,000 tons of coal are annually distilled for the manufacture of coal-gas in this country, and the ammoniacal water of the gas works contains the salts of ammonia in solution.

According to the most reliable data 100 tons of coal when distilled so as to yield 10,000 cubic feet of gas of specific gravity 0·6, give the following products, in tons:—

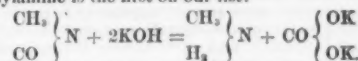| Gas.	Tar.	Ammonia Water.	Coke.	
2·25	8·5	9·5	59·75	Average.

This ammonia water contains about 1·5 per cent. of ammonia; hence the total quantity of the volatile alkali obtainable from the gas works in England amounts to some 9,000 tons per annum.

A singular difference is observed between the dry distillation of altered woody fiber as we have it in coal—and woody fiber itself. In the products of the first operation we chiefly find in the tar the aromatic hydrocarbons such as benzene, whilst in the second we find acetic acid and methyl-alcohol are predominant.
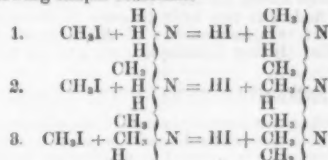
The year 1848 is a memorable one in the annals of revolutionary chemistry, for in that year Wurtz proved that ammonia is in reality only one member of a very large family.

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* Lecture given at the Royal Institution by Prof. Roscoe. LL.D., F.R.S., February 21, 1879. Revised by the Author.—Nature

By acting with caustic potash on the nitriles of the alcohol radicals, he obtained the first series of the large class of compound ammonias, the primary monamines. Of these, methylamine is the first on our list:

$$\left.\begin{array}{l} CH_3 \\ CO \end{array}\right\}N + 2KOH = \left.\begin{array}{l} CH_3 \\ H_2 \end{array}\right\}N + CO\left\{\begin{array}{l} OK \\ OK. \end{array}\right.$$

The years that followed, 1849–51, were prolific in ammoniacal discovery. Hofmann pointed out that not only one atom of hydrogen in ammonia can be replaced by its equivalent of organic radical, but that either two or all of the three atoms of the hydrogen in ammonia can be likewise replaced, giving rise to the secondary and tertiary amines by the following simple reactions:—

$$1. \quad CH_3I + \left.\begin{array}{l} H \\ H \\ H \end{array}\right\}N = HI + \left.\begin{array}{l} CH_3 \\ H \\ H \end{array}\right\}N$$

$$2. \quad CH_3I + \left.\begin{array}{l} CH_3 \\ H \\ H \end{array}\right\}N = HI + \left.\begin{array}{l} CH_3 \\ CH_3 \\ H \end{array}\right\}N$$

$$3. \quad CH_3I + \left.\begin{array}{l} CH_3 \\ CH_3 \\ H \end{array}\right\}N = HI + \left.\begin{array}{l} CH_3 \\ CH_3 \\ CH_3 \end{array}\right\}N$$

To these bodies the names of methylamine, dimethylamine, and trimethylamine were respectively given. They resemble ammonia in being volatile alkaline liquids or gases, which combine with acids to form crystallizable and well defined salts.

Hitherto, these compound ammonias have been chemical curiosities; they have, however, recently become—as has so often been the case in other instances—of great commercial importance, and are now manufactured on a large scale.

We are all well aware that the French beet-root sugar industry is one of great magnitude, and that it has been largely extended in late years. In this industry, as in the manufacture of cane sugar, large quantities of molasses or treacle remain behind after the whole of the crystallizable sugar has been withdrawn. These molasses are invariably employed to yield alcohol by fermentation. The juice of the beet, as well as that of the sugar cane, contains, in addition to the sugar, a large quantity of extractive and nitrogenous matters, together with considerable quantities of alkaline salts. In our sugar producing colonies, the waste liquors or spent-wash from the still—called vinasses in French—are wastefully and ignorantly thrown away instead of being returned to the land as a fertilizer, and thus the soil becomes impoverished.

In France it has long been the custom of the distiller to evaporate these liquors (vinasses) to dryness, and calcine the mass in a reverberatory furnace, thus destroying the whole of the organic matter but recovering the alkaline salts of the beet root. In this way 2,000 tons of carbonate of potash are annually produced in the French distilleries. More than thirty years ago the idea was entertained of collecting the ammonia water, tar, and oils which are given off when this organic matter is calcined, but the practical realization of this project has only quite recently been accomplished, and a most unexpected new field of chemical industry thus opened out through the persevering and sagacious labors of M. Camille Vincent, of Paris.

The following is an outline of the process carried out at the large distillery of Messrs. Tilloy, Delaune & Co., at Courrières. The spent wash, having been evaporated until it has attained a specific gravity of 1·81, is allowed to run into cast iron retorts, in which it is submitted to dry distillation. This process lasts four hours, the volatile products pass over, whilst a residue of porous charcoal and alkaline salts is left behind in the retort. The gaseous products given off during the distillation are passed through coolers, in order to condense all the portions which are liquid or solid at the ordinary temperature, and the combustible gases pass on uncondensed, and to serve as fuel for heating the retorts.

The liquid portion of the distillate is a very complete mixture of chemical compounds resembling, in this respect, the corresponding product in the manufacture of coal gas. Like this latter, the liquid distillate from the spent wash may
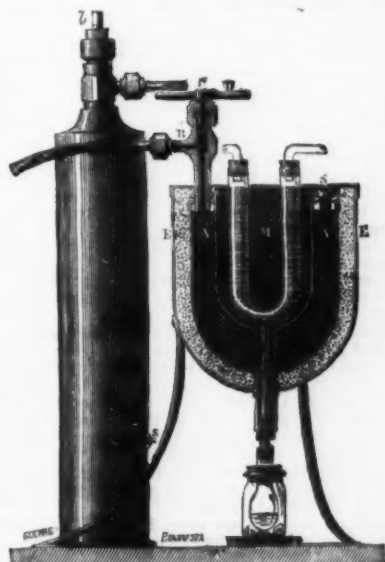
FIG. 2.—THE RECEIVER AND FREEZER

be divided into: 1. The ammonia water; 2. The tar. The ammonia water of the vinasses resembles that of the coal gas manufacture, in so far as it contains the carbonate, sulphydrate, and hydrocyanide of ammonia; but it differs from this (and approximates to the products of the dry distillation of wood) by containing, in addition, methyl alcohol, methyl sulphide, methyl cyanide, many of the members of the fatty acid series, and most remarkable of all, large quantities of the salts of trimethylamine.

The tar, on redistillation, yields more ammonia water, a large number of oils, the alkaloids of the pyridene series, solid hydrocarbons, carbolic acid, and lastly, a pitch of fine quality.

The crude alkaline aqueous distillate is first neutralized by sulphuric acid, and the saline solution evaporated, when crystals of sulphate of ammonia are deposited, and these, after separating and draining off, leave a mother liquor, which contains the more soluble sulphate of trimethylamine. During the process of concentration, vapors of methyl alcohol, methyl cyanide, and other nitriles, are given off; these are condensed, and the cyanide used for the preparation of ammonia and acetic acid by decomposing it with an alkali.

Trimethylamine itself is at present of no commercial value, though we are not without hopes that a useful employment for this substance may soon be found. The question arises as to how this material can be made to yield substances capable of ready application in the arts. This problem has been solved by M. Vincent in a most ingenious way. He finds that the hydrochlorate of trimethylamine, when heated to a temperature of 260°, decomposes into (1) ammonia, (2) free trimethylamine, and (3) chloride of methyl:

$$3NMe_3HCl = 2NMe_3 + NH_3 + 3MeCl.$$

By bubbling the vapors through hydrochloric acid, the alkaline gases are retained, and the gaseous chloride of methyl passes on to be purified by washing with dilute caustic soda and drying with strong sulphuric acid. This is then collected in a gas holder, whence it is pumped into strong receivers and liquefied. The construction of one of these is shown in Fig. 1. They consist of strong wrought iron cylinders, tested to resist a pressure of 20 kilos per square centimeter, and containing 50, 110, or 220 kilos of chloride of methyl. The liquid is drawn from these receivers by opening the screw tap, D, which is covered by a cap, C, to prevent injury during transit.

Both ammonia and chloride of methyl are, however, substances possessing a considerable commercial value. The latter compound has up to this time, indeed, not been obtained in large quantities, but it can be employed for two distinct purposes: 1. It serves as a means of producing artificial cold; 2. It is most valuable for preparing certain methylated dyes, which are at present costly, inasmuch as they have hitherto been obtained by the use of methyl iodide, an expensive substance.

Methyl chloride was discovered in 1840 by MM. Dumas and Peligot, who obtained it by heating a mixture of common salt, methyl alcohol, and sulphuric acid. It is a gas at the ordinary temperature, possesses an ethereal smell and a sweet taste, and its specific gravity is 1·738. It is somewhat soluble in water (about 3 volumes), but much more in acetic acid (40 volumes), and in alcohol (35 volumes). It burns with a luminous flame tinged at the edges with green, yielding carbonic and hydrochloric acids. Under pressure, methyl chloride can readily be condensed to a colorless, very mobile liquid, boiling at −23 C. under a pressure of 760 mm. As the tension of the vapor is not high, and as it does not increase very rapidly with the temperature, the liquefaction can be readily effected, and the collection and transport of the liquefied chloride can be carried on without danger. The following table shows the tension of chloride of methyl at varying temperatures:

At	0°	the tension of CH_3Cl is	2·48	atmospheres.
"	15°	"	4·11	"
"	20°	"	4·81	"
"	25°	"	5·62	"
"	30°	"	6·50	"
"	35°	"	7·50	"

From these numbers we must of course subtract 1 to obtain the pressure which the vapor exerts upon the containing vessel.

As a means of producing low temperatures chloride of methyl will prove of great service both in the laboratory and on a larger industrial scale. When the liquid is allowed to escape from the receiver into an open vessel, it begins to boil, and in a few moments the temperature of the liquid is lowered by the ebullition below −23°, the boiling point of the chloride. The liquid then remains for a length of time in a quiescent state, and may be used as a freezing agent. By increasing the rapidity of the evaporation by means of a current of air blown through the liquid, or better, by placing the liquid in connection with a good air pump, the temperature of the liquid can in a few minutes be reduced to −55°, and large masses of mercury easily solidified.

The construction of a small copper receiver and of the freezing machine employed by M. Camille Vincent is shown in Fig. 2. It consists of a double cased copper vessel, between the two sides of which the methyl chloride is introduced. The central space is filled with some liquid such as alcohol, incapable of solidification. The chloride of methyl is allowed to enter by the screw tap, B, and the screw, S, left open to permit of the escape of the gas. As soon as the whole mass of liquid has been reduced to a temperature of −23° the ebullition ceases, the screw, S, may be replaced, and if a temperature lower than −28° be required the tube, B, placed in connection with a good air pump. By this simple means a liter of alcohol can be kept for several hours at temperatures either of −28° or −55°, and thus a large number of experiments can be performed for which hitherto the expensive liquid nitrous oxide or solid carbonic acid was required.

M. Camille Vincent has recently constructed a much larger and more perfect and continuous form of freezing machine, in which, by means of an air pump and a forcing pump, the chloride of methyl is evaporated in the freezing machine, and again condensed in the cylinders. This enlarged form of apparatus will probably compete favorably with the ether and sulphurous acid freezing machines now in use, as they can be simply constructed, and as the vapor and liquid employed does not attack metal, is non-poisonous, and as the frigorific effects which it is capable of producing are more energetic.

The second and perhaps more important application of methyl chloride is to the manufacture of methylated colors.

It is well known that rosaniline or aniline red, $C_{20}H_{19}N_3$, yields compounds possessing a fine blue violet or green color, when a portion of the hydrogen has been replaced by the radicals, methyl or ethyl, and the larger the proportion of hydrogen replaced, the deeper is the shade of violet produced. Then we have triethyl rosaniline, or Hofmann's* violet, $C_{20}H_{16}(C_2H_5)_3N_3$.

By the replacing one or two atoms of the hydrogen of aniline by methyl, and by oxidizing the methyl aniline, Charles Lauth obtained fine violet colors, whilst about the same time Hofmann observed the production of a bright green coloring matter now known as iodine green, formed during the manufacture of the violet, and produced from this latter color by the action of methyl-iodine.

* Hofmann, Proc. Roy. Soc., xiii. 13 (1865).

In order to prepare aniline green from the pure chloride of methyl a solution of methyl-aniline violet in methyl-alcohol is placed in an iron digester, and the liquid rendered alkaline by caustic soda. Having closed the digester, a given quantity of liquid chloride of methyl is added by opening a tap, and the digester thus charged is placed in a water bath, heated by a jet of steam until the temperature reaches 95°, and the indicated pressure amounts to from 4 to 5 atmospheres. As soon as the reaction is complete the hot water is replaced by cold, and the internal pressure reduced by opening the screw tap of the digester. The product of this reaction, heated and filtered, yields the soluble and colorless base, whose salts are green. To the acidified solution a zinc salt is added to form a double salt, and the green compound is then precipitated by the addition of common salt. By adding ammonia to a solution of the methyl green salt, a colorless liquid is obtained in which cloth mordanted with tannic acid and tartar-emetic becomes dyed green (R. S. Dale).

If rosaniline be substituted for methyl-aniline in the preceding reaction, Hofmann's violet is obtained. The application of methyl-chloride to the preparation of violets and greens is, however, it must be remembered, not due to M. Vincent; it has been practiced for some years by various aniline color makers. M. Vincent's merit is in establishing a cheap method by which perfectly pure chloride of methyl can be obtained, and thus rendering the process of the manufacture of colors much more certain than it has hitherto been. By the use of this material the aniline can be methylated in simple cast-iron boilers heated by steam, and under a pressure much more moderate than is otherwise required.

In reviewing the new chemical industry of the beet-root vinasses one cannot help being struck by the knowledge and ability which have been so successfully expended by M. Camille Vincent on the working out of the processes. Here again we have another instance of the utilization of waste chemical products, and of the preparation on a gigantic scale of compounds hitherto known only as chemical rarities. All those interested in the progress of scientific research must congratulate M. Camille Vincent on this most successful issue of his labors.

THE DISTILLATION OF COAL TAR—THE SCOTCH SYSTEM.

THE last distillate, which we may call re-run naphtha, is treated with sulphuric acid, followed by caustic soda. Lime may be substituted for the latter, as being an economical substitute, but it requires far more care, and, if used in excess, will cause trouble and additional work, which, with such volatile products, always involves loss.

The apparatus shown in Fig. 1 is well adapted for the purpose of the treatment of the re-run naphthas with sulphuric acid and caustic soda. A large wooden or iron vessel, a b c d, tapered towards the bottom, is lined with lead. The soldering is preferably done by the blow pipe, in the same manner as sulphuric acid chambers. It is securely fixed
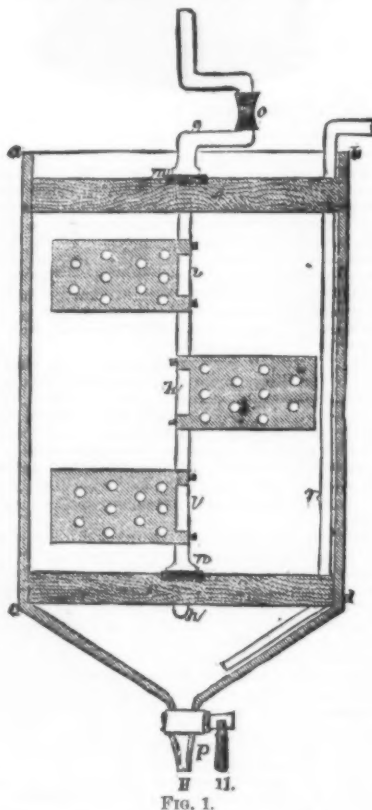

FIG. 1.

in a vertical position. Two horizontal beams, e and f, made of wood, covered with lead, or, if preferred, of cast iron, serve to support the shaft, g h. Fixed to this shaft by pinching screws are three cast iron blades, i k l. They are pierced with holes about an inch in diameter. If desired, they may be made of wood, covered with lead. The shaft works on cast metal bearings at m and n. The shaft, g h, is bent, at its upper extremity, into a crank having a loose cylinder of iron piping at o to facilitate the rotation in the workman's hands. In most cases it is better to have this done by a steam engine. The top, p, enables the contents of the mixing apparatus to be removed, but it is more especially used for drawing off the "sludge." The "sludge" is the tarry fluids which result from the action of sulphuric acid upon the olefines, the bases, and other impurities contained in the re-run naphtha.

The blades, i k l, are so placed as to escape the sides of the cylinder, a b c d, by a sufficient space to allow the siphon, q r, to reach nearly to the bottom. This siphon is connected with the pump which charges the rectifying still.

Four hundred gallons of re-run naphtha having been pumped into the agitator, four and a half gallons of strong

sulphuric acid are added, the agitator being worked briskly during the addition. The acid is not poured at once into the naphtha, but is made to fall into it in the form of fine rain, so as to promote its thorough incorporation. With this view two leaden gutters, a b c d, Fig. 2, are laid across the top of the agitator. They rest on two movable pieces of wood, e f, which, during the addition of the acid, rest on the upper edge of the apparatus. The gutters are pierced with a great number of very fine holes, which serve to distribute the acid. The agitation should be kept up for five minutes. The whole is then allowed to rest for about the same time. The "sludge" is then to be run off by the stopcock, p, great care being taken to prevent any naphtha running away at the same time. The entire operation is then to be repeated, precaution being taken not to keep up the agitation long enough to allow the charge to heat. Some operators repeat the operation once more with the same quantities, but, instead of using the sulphuric acid alone, a mixture of nitric and sulphuric acid is employed. The proportions for this
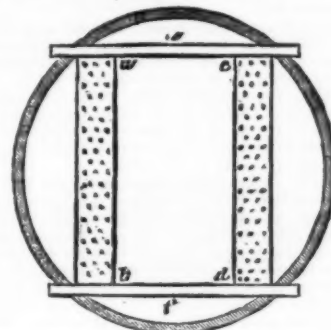

FIG. 2.

purpose are nine parts of sulphuric acid by measure to one part of nitric acid of a specific gravity of 1·45, or thereabouts. If this nitro-sulphuric be used, a considerable quantity should be prepared at one time; it may then be stored in glass carboys. The addition of the nitro-sulphuric acid is to be made very gradually, so as to slowly raise the temperature to about 60° C., — 140° Fahr. If the temperature rises higher, the agitation and addition of the acid must be arrested. The object of raising the temperature to this point is to prevent the naphtha acquiring a brown tint on keeping. Other proportions of acid, etc., will be found in treating of the French method of conducting the purification. The French tar distillers also use nitro-sulphuric acid.

After the "sludge" has been run off, 5 gallons of cold water are to be added gradually, with thorough agitation, the settling and running off to be repeated as usual. It is now necessary to remove the last traces of acid by means of caustic soda. The best strength for the purpose is about 70° of Twaddell's scale, which is represented by a specific gravity of 1·350. It must not be forgotten that the agitator must be provided with a well-fitting cover, to avoid the loss of the more volatile hydrocarbons by evaporation.

After settling for a sufficient length of time, the purified naphtha may be pumped into the finishing or rectifying still. An excellent still for this purpose will be described under the French process; but, if the old fashioned plan of rectifying in an ordinary still in a current of steam be adopted, great care must be taken that the condensing arrangement is sufficiently powerful to prevent any loss of the more volatile hydrocarbons. The mixture of water and naphtha distilling over should at no time be perceptibly warm to the hand.

The first puncheon distilled should, if the tar be of first-rate quality, contain 30 or 40 per cent. of benzole, according to the mode of testing described in the introduction. The second puncheon will be of the finest class of naphtha for dissolving purposes, and the rest will be an excellent burning naphtha. The residue in the still contains naphtha of high boiling point, and a considerable quantity of naphthalene. It may be distilled with proper precautions, either with the naked fire, or by means of superheated steam. It will then yield an oil sufficiently good for burning in the blast lamps used in iron foundries, etc.

The naphtha prepared by the above processes should be of extremely good odor, absolutely colorless, and perfectly neutral. Water shaken up with it, and then separated, should not redden litmus paper; and there should not be the faintest smell of naphthalene when a little has been allowed to evaporate on the hand. It should also keep perfectly colorless for at least twelve months.

It would be easy to describe a vast number of modifications of the general process for working coal naphtha; but it is quite unnecessary, because the method given is capable, if properly carried out, of yielding excellent results. The agitator, Fig. 1, may, if preferred, be made horizontal instead of vertical; but, for coal naphtha, there are some advantages in the form given. The treatments with caustic soda may be made in a separate agitator to that used for the sulphuric acid; and where the quantity of naphtha made is very large, there are certain advantages in such an arrangement.

It is absolutely necessary, for the reasons previously given, that all the apparatus connected with the distillation and purification of coal naphtha, should be as far as possible from any fire. It is also proper to have a hose, connected with a plentiful source of water at high pressure, always in readiness. It must be remembered, however, that water will not extinguish burning naphtha; it is therefore only useful as a cooling agent, and to extinguish burning woodwork. It follows as a corollary that there should be as little wood as possible used in the construction of the buildings of a tar factory. It will also be found that the premiums of insurance are much lessened if the buildings are so arranged as to render the communication of fire from one to the other difficult, or, still better, impossible. It is a good plan to have a large heap of sand in the yard, and several hand barrows, as the writer has often either extinguished or arrested the spread of fire by this means.

It is also a good rule to strictly prohibit any of the men or lads from ever running from one part of the yard to another, unless in the event of accident; it will then be known, and proper precautions taken at once. Smoking in the yard or factory should lead to the immediate dismissal of the culprit. No light should ever be allowed in the still-house on any pretense. It is very easy to have lights so arranged, that during the short days of winter the work can proceed all night, if necessary, without any danger to life or property. One method is thus carried out: A square aperture is

made in the wall, in a convenient place. It is lined with tin plate, to act as a reflector. It is completely glazed on the inside, so that no vapors can reach the gas flame, unless the glass be broken. To lessen the chances of this a coarse wire netting is placed in front of the glass. At the back, that is to say, on the outside of the still house, is an iron or zinc door which may also be glazed, so that the light is utilized in the yard. A gas lamp is fixed inside the square chamber formed as described. The gas flame must be so placed as to render the cracking of the front glass by its heat impossible. It is a proper precaution to protect the back as well as the front glass by wire netting, because a stone thrown at the back window would fracture the front one, unless this precaution were taken.—*Journal of Gas Lighting.*

THE TREATMENT OF ORGANIC HEART DISEASE.*

I HAD spoken to you, at my last lecture, I think, of those cases of heart disease in which there is no failure of power but rather an undue amount of force, and had mentioned the sedative treatment as the proper one. I also had alluded, I think, to those cases in which there is considerable obstruction to the circulation and a marked deficiency of power. The treatment in such cases I told you was (1) to conserve or save the power of the heart as much as possible; (2) to prevent functional derangement; (3) to regulate cardiac action; and (4) if possible, to remove the original lesion.

Under the first head I dwelt upon the importance of rest. Now there are a great many cases of heart disease in which the heart is so strong that the patient need not be obliged to give up his business, and may be allowed to remain at work, provided he is moderate and avoids all wear and tear. Gentle moderate walking is of the greatest service to such patients. There must be no needless running hither and thither. If this rule is observed it is wonderful how long the natural vigor of the system will remain unabated. To maintain the heart, in addition to moderate exercise, good food is requisite.

There is no danger of sudden deaths occurring in such cases if the patient will only take things moderately. Sudden death from heart disease occurs usually from one of two causes: (1) where the heart has gone on to extreme fatty degeneration, so that the slightest strain causes rupture of its walls, and (2) where from the same cause, viz.—a sudden strain—so much stress of work is thrown upon the heart as to bring it to an unexpected and final halt. Moderate exercise may always be indulged in without any danger of sudden stoppage of the heart. It is a great mistake to slur over this point in your dealings with your patient. The patient's friends, perhaps, have led him to believe that death may overtake him at any moment, and if you desire to eradicate this idea from his mind you must be entirely frank in your dealings with him.

In other cases where heart failure is marked I dwelt upon the importance of an extreme degree of rest, kneading of the muscles and very gentle exercise only being enjoined. Where there are marked secondary congestions this is very important.

I called attention, also, in my last lecture to the indications and counter-indications for diet. The diet must be cautiously adapted to the patient's wants. I directed your thoughts also to the fact that in serious heart disease more distress is caused by over than under eating. Nothing more should be taken in the evening than a cup of broth or a glass of milk. If the patient be much exhausted some whisky or brandy may be given with the milk.

Passing, then, from these questions of rest and diet which I discussed pretty fully when I was last with you, let me now speak of the other indications, viz.: (1) the treatment of the functional embarrassment; (2) of the cardiac distress, and (3) of the original heart-lesion itself.

The first head embraces all the various kinds of local congestions and effusions. No part of the body is safe from these. The symptoms are referable to every organ, and relief to the central lesion affords relief to these local symptoms. When the nerves, or kidneys, or stomach are deranged, and all out of sorts, you may be sure that the distress comes from the condition of the central organ. First, then, in these cases, direct your treatment to the heart itself, and do not be hasty to apply special remedies, such as nerve tonics, or anodynes, or antispasmodics for the nervousness, or to quiet the cough. These remedies may interfere with the digestion, disorder the stomach, dam back the blood, and so radically increase the cardiac distress. All the symptoms will subside if the heart be but properly treated.

For the relief of congestions the best remedies are counter-irritants applied over the affected part. Where nervous and head symptoms predominate apply dry cups to the nape of the neck, over the posterior part of the chest for pulmonary congestion, and over the kidneys and liver for renal or hepatic hyperæmia. Use such remedies, in fact, as increase the discharge of a thin, watery secretion from the affected organ. In pulmonary congestion, joined with counter-irritants externally, muriate of ammonia given internally is exceedingly serviceable. In cerebral congestion advantage may be gained from the use of the bromides. In gastric congestion use the salts of mercury. These should not be given for their constitutional, but for their local effects. Their use should not be persevered in for any length of time. The best form for occasional use is blue mass.

When the appetite is poor, the stools insufficient, the liver tender upon palpation, the secretions of the intestines scanty, blue pills, followed by a saline laxative, often afford extraordinary relief. These remedies will relieve the nervous and cerebral symptoms and reduce the pulmonary congestion. The rales will disappear and the breathing become easier. Relief of the circulatory embarrassment will also follow.

The liver is the organ most frequently attacked, but when one organ suffers all the others sympathize. There is an increased stasis of blood in every other part. The liver is particularly predisposed to passive congestions. Next to the liver, in point of the frequency with which they are attacked, come the stomach and spleen. The best remedy for these conditions, as I have just told you, consists in mercury, followed by a mild saline laxative, and in the use of counter-irritants externally applied.

In congestion of the kidneys with albuminuria, which often occurs, you may make up your mind that there is no organic renal disease, provided the urine contains no tube casts. When no tube casts are present the relief obtained by means of the proper treatment will be entire. Renal and hepatic congestion are often associated. Where this is the case the portal circulation should be depleted by means of a

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saline laxative, and the congestion of the kidneys relieved by means of digitalis, together with a saline diuretic.

Digitalis is very often indicated on account of its action upon the heart. But rarely, indeed, are we unable to use it.

If there be an anæmic state of the system, with watery blood and deficiency of red globules, iron is usually well borne, and relieves the renal congestion. Its use, however, requires great caution and judgment. Generally, in disease of the heart, there is a condition of plethora—a strong contra-indication to the use of iron, but sometimes the oxidization of the blood is not properly performed and the nutrition is imperfect, and hydræmia supervenes. Here, although there is too much blood, what there is of it is too poor. Passive congestions, dependent upon poverty of the blood and deficiency in circulation, will bear iron, together with diuretics and saline laxatives. The best form of administration is in a laxative ferruginous water, or a diuretic ferruginous mineral water, or in the shape of Basham's mixture. So much for the congestive functional disorders.

We now come to the consideration of the treatment of dropsies in the form of œdema, or anasarca, or ascites, or hydrothorax, or hydropericarditis. So, too, with regard to the venous stases which relieve themselves by passive transudation.

In treating these conditions properly we must first treat the heart, and then the distended vessels. Dropsies, as a general thing, may be separated into three groups: (1) general anasarca; (2) ascites, with portal congestion; (3) hydrothorax, with stasis of the blood in the azygos veins.

In the treatment of dropsies as complications of organic heart disease, counter-irritants are usually of great service—cups, blisters, iodine painted on the surface, or iodine with croton oil. These all draw the blood to the surface and deplete the over-distended vessels. But dropsy, as a general rule, demands more powerful measures. And here we first fall back on diet, for operative measures should always be regarded as a *dernier ressort.* If serum can only be absorbed we all know that it is just as nutritive as whey or milk. Try, therefore, to produce absorption by all the means in your power. While the congestion continues, the dropsy will continue. At the same time careful attention must be paid to rest and hygiene.

In some cases these three things, rest, diet, and hygiene, may be enough to cure dropsy. It is really wonderful how many cures have been effected by rest and a skimmed milk diet. In this way the effusion may all, in time, be absorbed.

In dropsy, as in the other complications of organic heart disease, it is very necessary (1) to attend to the disturbed heart, and (2) to resort to means for the discharge of liquids from the body.

In cases of anasarca the most rapid relief is obtained by the use of jaborandi, and excepting where we have a very bad heart to deal with, jaborandi is perfectly safe. Where the heart is very weak, we fear the effects of the collapse which always follows profound sweating. In such cases we should always have ammonia and brandy at hand to administer in case of any danger of stoppage of the heart. Where jaborandi is out of the question, laxatives, saline diuretics, or the warm vapor bath may be employed.

Ascites is properly treated by saline laxatives. Hydrothorax by diaphoretics and diuretics, the salts of potassium, iodide and acetate, with digitalis. Very often, in spite of careful diet, absolute rest, cardiac stimulants, diaphoretics, and diuretics, the case continues to progress from bad to worse. Then we have to resort to operative measures, paracentesis thoracis, or abdominalis, or tapping. The two former operations are entirely free from danger, if properly performed. Both of them give relief, but being bungling and mechanical, only do so for a time, and should, therefore, never be attempted except when all other measures fail.

Caution is very desirable in the treatment of diseases of the heart. The physician should always be on his guard for the development of complications. A latent effusion may gain much headway without any outward sign. Remedies are of no avail apparently, the patient steadily grows worse, and it is not until the *post mortem* examination that a latent effusion is revealed. You should, therefore, always periodically go over your patient's whole body from head to foot —examine his urine, chest, liver, lungs, and stomach, and be sure that no effusion is gaining headway. The development of sudden symptoms is generally due to indirect secondary disturbance.

Of the removal of serum from subcutaneous tissue by tapping I must speak to you more at length. As long as you can get rid of general anasarca by medicinal means stick to them. The operation in this case is much more serious than in either of the others just mentioned.

The dropsy mounts up the legs, involves the scrotum, producing œdema, and attacks the penis, rendering it anasarcous; twists it on itself so that natural urination is entirely out of the question, and a flexible catheter has to be kept in the bladder for weeks at a time. The various functions are seriously interfered with. The mere contact of anything with the skin sets up eczema, which at once runs into ulceration and sloughing. The general anasarca of organic heart disease is a most serious condition.

I have had this second patient brought in that he might serve as an illustration of some points in connection with this complication. In his case organic heart disease and renal disease are combined. Whether as separate diseases or not we could never say—mitral regurgitance, with chronic nephritis. The anasarca in his case has been most frightful. At first he had pulmonary œdema so badly that every night there seemed to be a fight with death. No sooner was this relieved than anasarca came on. This was so obstinate that we were obliged to resort at last to the operative treatment. We used (1) local vapor baths, and (2) we made a number of minute punctures in the skin of the legs with very delicate needles, or with a sharp bistoury. These punctures should never be made unless you are obliged to resort to operative measures, and they should be repeated just as rarely as possible. Otherwise sloughing or erysipelas may follow and lead to the entire death of the skin.

In this case the anasarca was so terrible that we had to resort to punctures twenty times in each leg during a period of two months, and every time we tapped it we drew at least three pints of serum from each leg, *i. e.,* we obtained in all 60 quarts of serum in sixty-one days. No sooner did we allow a limb to go untapped for even three days at a time than it grew so big that the patient could not move it, and, worst of all, the pulmonary œdema would come back, causing marked dyspnœa, which nothing removed.

As a result of our tapping you see the condition which the right leg presents—a most dreadful slough with all the tissues laid bare down to the muscle. There is of course no possibility of restoration. Since the sloughing has commenced the dropsy has all disappeared. The drain of pus upon the system, however, is so terrible that scarcely any strength can endure it.

In spite of all this combination of ills, however, the man has had a very good time during the winter; has been cheerful and merry and has really seemed to enjoy life. I may possibly be able to check that ulcerative action. It is hard to say how far the puncturing has been the cause of it in this case, for the leg would have sloughed if it had not been tapped.

It is barely possible that punctures made with a disinfected needle would not be followed by sloughing, and that sponges dipped in a carbolic acid solution and applied over the punctures will act as absorbents, will not check the flow of serum, and will prevent any unhealthy conditions of the parts, but I doubt it.

This brings us to a consideration of the treatment of the heart lesion itself.

We frequently find mixed up with the organic lesion a faulty condition of the nerve centers presiding over cardiac action, and unless these nerves are regulated the heart is, of necessity, still further embarrassed. There are very few cases of organic heart disease that do not present traces of functional nervous irregularity.

There are certain remedies which afford relief in these cases. That is, unless the ganglia themselves in the muscular substance of the heart are degenerated, which is often the case. The drug of most value is digitalis, and it is needed in all cases from time to time. It may be given in the form either of an infusion, or of a tincture, or in the shape of digitalin. It is needless to say that digitalis is not a universal remedy. In many cases it is not borne by the stomach; particularly is this the case if that organ is deranged and congested. This difficulty may be averted in some cases by the use of the infusion, or of digitalin. But after all digitalis is only directed to one part, and the hygienic measures are those of most importance.

But when the pulse runs from 95 to 110 to the minute, particularly if the separate contractions of the heart are evidently inefficient and the pulse is weak and small—if, in other words, there is a manifest want of power, digitalis is an unrivaled remedy.

The indications for its use then are insufficiency of contraction on the part of the walls of the heart as shown by feeble, imperfect sounds and weak pulse, particularly if associated with frequent and irregular action. When the heart is slow and feeble, digitalis does not exert by any means so advantageous an action.

Digitalis may, as I have already remarked, disagree with the stomach and so increase the cardiac distress by reflex irritation. It must therefore be used cautiously and discreetly. Where it is well borne it may be given up to the production of its physiological action. Give it therefore, if necessary, in increasing doses. Give it freely—there is no fear of a cumulative action, if the dose be increased cautiously. The usual dose of the tincture is gtt. x., of the infusion f. ℥ j., and of digitalin gr 1-60th every three hours. In spells of awful cardiac disturbance larger doses are of course necessary, but as a general thing the quantities which I have just specified will be found to be sufficient.

Among other drugs, belladonna is of value, particularly where the heart's action is strong, but irregular. I have also frequently derived most excellent results from the use of the bromides. In cases where the heart is feeble, its muscles weak, and passive secondary congestions rife, quinia and strychnia do great good.

The last question of treatment is with regard to the management of the heart-lesion itself. Concerning this I have but few words to say. Where the lesion is inflammatory the iodide of potassium should be employed in long-continued doses. In young subjects I have often obtained very positive relief from the conscientious use of this remedy. Where the lesion is of a degenerative type I use cod-liver oil, the iodide of iron, and arsenic. These exert a slow but beneficial influence.

The foregoing has been a very sketchy discussion of a very large question. I hope that what I have said may lead you to regard organic heart disease as a systematic disease, and one which demands the most careful thought and study for the proper understanding and application of treatment. Give it, above all things, sound physiological and hygienic care. Let your treatment be simple, and treat each case separately. The principles of its treatment are uniform. If you but gain a clear idea of them the details will easily follow.

SUGGESTIONS FOR PREVENTING THE SPREAD OF SCARLET FEVER.*

SCARLET FEVER, scarlatina, scarlet rash, canker-rash, and rash fever are names of a contagious and infectious disease of varying degrees of severity; but in which all the forms are capable of conveying the most severe type. A person may become ill with fatal scarlet fever from association with another who had so mild an attack of the disease as not to keep him in the house, much less in bed.

The hypothesis of a "germ" in scarlet fever, analogous to the spores of minute vegetable growths, which is of organic nature and capable of indefinite multiplication outside of the body, is maintained by some scientific observers, but is held by other authorities to be at variance with many observed facts.

It is generally agreed among sanitarians that scarlet fever is conveyed from one person to another by means of the epithelium or thin superficial covering which extends over the whole body, under the name of epidermis, cuticle, or scarf-skin, and which also lines the inner passages of the body. The exhalations from the outer and inner surfaces of the various parts of the body, and from the excretions also, are capable of transmitting the disease. Upon whatever the contagious matter depends for its dangerous character, it is capable of retaining its power to carry the disease for a long time—certainly many months, and possibly for a year or more—unless destroyed.

The means of transporting the contagium of scarlet fever may be furnished by anything that has come in contact with an infected person or object—air, food, clothing, sheets, blankets, whiskers, hair, furniture, toys, library books, wall paper, curtains, cats, dogs, etc. Funerals have occasionally spread the disease, the exhalations from the dead body being also dangerous.

The period from exposure which results in scarlet fever, to the time when the symptoms manifest themselves, varies from several hours to three, and possibly four, weeks. The average time is variously given from six to eight or ten days.

The time at which one who has been ill with scarlet fever may safely mingle with other people is not always easy to determine; but it is, for convenience, usually placed by sanitarians at four weeks from the commencement of the illness, as that covers the vast majority of cases, and it is

best to have some arbitrary rule. A physician's certificate, however, should always be required.

It would be well to designate every house where scarlet fever exists, by some mark not too conspicuous, and yet sufficient to give the proper information.

The first principle of treatment is in isolation, which can be nowhere so well observed as in a hospital, provided the patient is old enough to go there. Otherwise he should be placed in a room as much separated from the rest of the house as possible, and communicate with no more members of the household than is absolutely necessary. If an outward draught of air from the sick room to the entry occurs, a curtain may be formed by a sheet which is soaked in some disinfectant; those which have not a disagreeable odor, and do not stain clothing, being preferred.

The sick room should be well warmed and ventilated (by an open fire place with a fire or a lamp in it, if possible). It should be open to the sun, as free as possible from noise, dust, etc., and not "aired" by cold draughts, which are often more dangerous than a foul atmosphere.

All carpets, upholstered furniture, window hangings, and indeed, unnecessary objects of every kind, especially woollen, should be removed from the room. Bits of carpet may be used, and burned after the need for them has passed.

The discharges from the throat, nose, and mouth of the patient may be put in a vessel containing a strong solution of some "disinfectant," which shall be frequently washed with hot water; they should not be received upon anything which is to be kept. Pieces of soft cloth, which should be at once burned, may be used in place of pockethandkerchiefs. The breath should be kept as pure as may be, by cleansing gargles and washes for the mouth (chlorinated soda, permanganate of potash, etc.). The discharges from the kidneys and bowels should be disinfected with boiling water, to which some deodorizer (nitrate of lead, chloride of zinc, sulphate of iron, carbolic acid, chloride of lime, etc.) may be added. Carbolic acid may be added as a "disinfectant" to the slops, and to the water in which the patient has washed, before throwing it out. The skin is usually more comfortable in feeling if cosmoline, etc., or sweet oil, with a couple of grains of camphor to the ounce, is used for anointing it; the scales of the epidermis are also thereby prevented, to a considerable degree, from escaping freely into the air. The bed clothes, towels, etc., when disused, should be removed with proper care, and be boiled for a couple of hours. The food left uneaten should never be carried where it may infect other persons.

While the sick room is occupied, it is doubtful whether any disinfectant can be used of sufficient strength to destroy the contagium. Many substances, however, do destroy organic matter by oxidation, and in that way at least contribute to cleanliness if nothing more. For that purpose it is desirable to use nitrate of lead, chlorinated soda, chloride of zinc, permanganate of potash, etc., because they do not stink of themselves. It has been thought that the ancient custom of burning aromatic balsams, etc., contributed powerfully to disinfection.

Attendants on the sick should be as few as possible, and should not communicate with other persons any more than can be helped. They should wear only such clothing as may be readily washed. Clothes used in the sick room should be boiled before being worn elsewhere. Gargling or washing the mouth occasionally with a cleansing fluid is a useful measure for those who must be exposed to contagion; and in washing the hands, a little Condy's fluid (permanganate of potash) may be placed in the basin.

After recovery, the patient should not mingle with other persons, use lounges, carriages, public rooms, etc., liable to be used by others, until the roughness of the skin has disappeared, and until he has taken warm baths for several days.

After the sick room is no longer needed as such, all the clothing and other matters used in it, that can be washed, should be soaked in boiling water; others should be placed in a hot air chamber, and kept at a temperature of 212° F. for several hours. Any articles of trifling value may be destroyed by fire. The wall paper should be soaked with carbolic acid, removed and burned. The ceiling should be washed with soap and hot water, or scraped. The room should then be closed as tight as possible, and as much sulphur burned in it as the air will allow (a pound is an abundant amount for an ordinary room); it should be kept closed from six to eight hours, and then opened for several days to the air and sunshine. The floor and wood-work should then be thoroughly washed with soap and hot water. Scraping and repainting would not be considered an excess of caution in time of epidemics.

Should the sick person die, the body ought not to be removed from the sick room until it has been sealed in the coffin, with carbonate of iron, carbolized earth, or some similar agent. It is advisable that the funeral should be as private as possible, and not attended by children.

Anything which deteriorates health tends to render the system liable to any disease; and in that sense filth may be considered to promote scarlet-fever, or to increase its mortality. Perfect cleanliness should, therefore, be enjoined. Sewer gas, of course, is a kind of filth which may bring to one person's chamber, if it has access thereto, the contagium brought from another chamber and not disinfected. Overcrowding is one of the most active ways of propagating contagious disease. Finally, fresh air is one of the best disinfectants.

DEATH RATE IN EUROPE.

A RUSSIAN statistician has lately undertaken to find out at what rate people die in Europe, and the results of his labors show the following yearly proportion of deaths out of every thousand souls:

Russia .... 37·5
Hungary .... 37·2
Bavaria .... 31·7
Würtemberg .... 31·7
Austria .... 31·3
Spain .... 30·5
Italy .... 30·3
Germany .... 27·8
France .... 26·3
Switzerland .... 23·8
Belgium .... 23·7
Great Britain .... 22·3
Denmark .... 19·5
Norway and Sweden .... 18·2

It will be seen from this that the mortality is greatest in Russia, whereas Norway and Sweden seem to be the healthiest of the countries. France ranks fourteenth on the list, and shows a slight advantage over Germany, but a difference for the worse of four per cent. between herself and

England. In the city of New York the death rate for the past year was 25·28 in every thousand; that is, we rank between France and Switzerland. In London, however, the death rate for 1877 was 21·79, a difference of 3·49 between the two towns. These figures show how much room there is for increased attention to the laws of hygiene.

ARCHÆOLOGICAL EXPLORATIONS IN TENNESSEE.

By F. W. PUTNAM, Curator of the Peabody Museum.

THE most important of my operations were those within the earthwork near Lebanon, in Wilson Co., and about 60

FIG. 31.—SHARPENING STONE FROM LARGE MOUND WITHIN EARTHWORK. NATURAL SIZE.
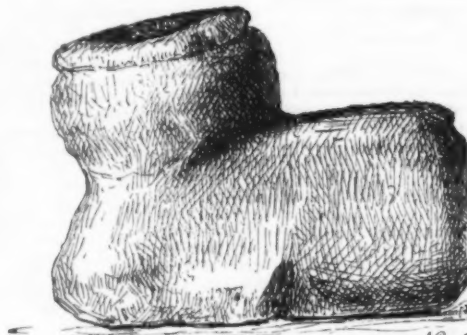

FIG. 35.—PIPE MADE OF SANDSTONE, FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK. NATURAL SIZE.

miles east from Nashville. At this place on the farm of Dr. Samuel Crockett, included in the estate of the Lindsley family, who were early settlers in the county, are the remains of an extensive settlement of the moundbuilders of Tennessee. Accepting the kind invitation of Mrs. N. Lawrence Lindsley, Principal of the Greenwood Seminary, I was enabled by her co-operation and the assistance of Mrs. Henry Lindsley, Dr. Crockett, and twenty-five workmen, to make, in a week's time, a comparatively thorough exploration of these remains, for an accurate survey of which, reproduced on the map heretofore given, I am indebted to Prof. J. H. Buchanan, of Lebanon.

As will be seen by an examination of the map, Spring

its outer edge is a crest about 6 inches high. The sections at the bottom of the map illustrate this structure; *a*, the outer, and *b*, the inner side of the ditch. At the eastern and southern portions of the inclosure are three causeways or openings through the embankment. Near the northwestern end, between the embankment and the creek, is a low mound, the existence of which I was not aware of until the survey was made by Prof. Buchanan, after the rank vegetation, which covered everything at the time of my visit, had been destroyed by the frosts. At this portion of the inclosure and to the southeast, the land is very low and in the time of spring floods must be washed by the overflow from the creek. To the westward the land rises, and at the southwestern corner of the inclosure there is a rocky portion 20 to 25 feet higher than along the eastern embankment. Still,

further to the southwest, near the creek, the land is 30 feet higher than at the point near the creek on the northern side. On this southern bluff are six mounds, only a few feet in height, situated as shown on the map. Two of these mounds I caused to be trenched, and found that they were constructed of earth and stones which had subsequently been heated and burned by long continued fires, and there was no indication of their having been used for any other purpose. In the ditch, on the western side, is a large elm tree 4 feet 2 inches in diameter. On the summit of the large mound within the inclosure were several large trees, among them a poplar 2½ feet in diameter and a hackberry 2 feet in diameter.
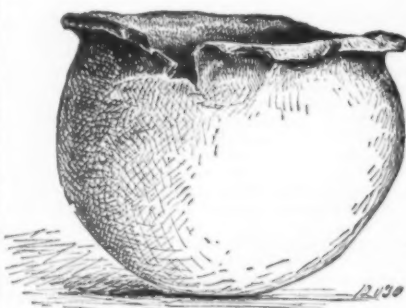

FIG. 32.—BOWL FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK.

FIG. 36.—POT FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK.

Creek, a tributary of the Cumberland, makes at this place a bend to the eastward, where there is a limestone bluff. In this bend, near its narrowest part, is located an earthwork inclosing an area of between ten and eleven acres, and having its greatest length, of about 900 feet, in a north-south direction, and a width from east to west of about 650 feet. At nearly regular distances along this embankment, on the inside, are slight elevations at the angles of the earthwork. These are now 18 in. higher than the embankment between

FIG. 33.—DISCOIDAL STONE FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK. NATURAL SIZE.

the angles, and slope uniformly to the bottom of the ditch, which was originally, probably, between 3 and 4 ft. in depth. Between the angles, the top of the inner wall is now not much over a foot above the general level, and the slope to the bottom of the ditch is divided into two parts by a level bench nearly 3 feet in width. The outside slope of the ditch, throughout, is uniform from top to bottom, and along

Many other trees of considerable size were growing within the inclosure and several large trees had fallen and gone to decay. While this tree growth does not, in all probability, give any approximation to the period when this ancient town was deserted, it at least points to a time before the intrusion of our own race, and everything found within the inclosure was confirmatory of the antiquity of the place. To the east of the embankment there is a depression following the curve of the wall on that side, indicated on the map by parallel dotted lines, which looks like a former channel of the creek; and it is very likely that when the earthwork was made, the creek flowed near the eastern wall, and has since cut its way four or five hundred feet farther to the eastward. The geological structure, contour of the land and direction of the natural flow of the creek, are all favorable to such a change in the course of centuries.

The first object of attention within the inclosure is the large mound, marked A on the map, and also shown in section at the bottom. This mound, as shown by the section (the shaded part in which represents the portion excavated), has steep sides and a flat top. Its dimensions are 138 feet by 120 at its base, and 95 by 75 feet on its summit, with a height of 15 feet. A trench was cut from the base of the eastern side and carried to the center; beginning with a width of 4 feet and gradually widening to 14. After the center was reached that portion was deepened to 18 feet from the summit, thus digging down 3 feet in the original soil, consisting of yellow gravel and clay, which was found to have been previously undisturbed. The earth of which the mound was composed was very hard, dry, and compact, and necessitated the use of the pick. The construction was the same as that of the Love Mound. At a depth of between 3 and 4 feet from the surface, near the center, were found three slabs of stone, each about 12 by 16 inches, a stone chip, piece of mica, fragment of pottery, and a discoidal piece of sandstone (Fig. 31), with several grooves upon its surface, indicating that it had been used as a sharpening stone. At a depth of between 7 and 8 feet was an ash bed that had evi-
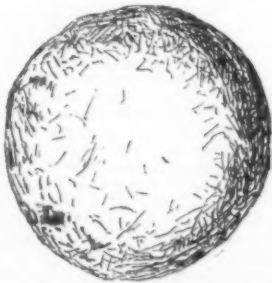
dently extended over the surface of the mound when at the height of 7 feet. In this bed of ashes were fragments of burnt bones, stones, and pottery; a discoidal stone, an arrowhead, flint chip, portion of a shell of a *Unio*, several burnt corn cobs, a piece of charcoal matting, etc. Under the ashes the earth was burnt to a depth of a few inches, showing that the ashes were the remains of a fire on the spot and not material brought to the mound. At the depth of 13 feet, a piece of cedar, a few inches in diameter and much decayed, was found standing upright, with its base below the surface of the earth upon which the mound had been erected. Between 14 and 15 feet, and thus on, or close to the original soil, was another extensive bed of ashes, in which a few burnt bones of deer and pieces of charcoal were found.

The examination, therefore, showed that this was not a

dish was a large bone of a deer's leg, which had been cut and broken, and near the dish was a small mass of graphite, a pebble, and a flint chip.

In another of the graves of this lowest tier were found the following articles: An ornament of very thin copper, which was originally circular and with a corrugated surface. Only fragments of this could be preserved, and its full size could not be determined, though it was probably 4 or 5 inches in diameter. An earthen pot, a dish, and the skull were also secured. The remainder of these oldest graves in the mound yielded only fragments of pottery. As the earth of the mound was very damp, the pottery was soft and the bones were much decayed, so that great difficulty was experienced in taking the articles out, and it was necessary to have the pottery carefully dried before it could be handled.

engineer of Iowa City, who has collected and published many facts about it:

"The observers," he says, "who stood near to the line of the meteor's flight, were quite overcome with fear, as it seemed to come down upon them with a rapid increase of size and brilliancy, many of them wishing for a place of safety, but not having the time to seek one. In this fright the animals took a part, horses shying, rearing, and plunging to get away, and dogs retreating and barking with signs of fear. The meteor gave out several marked flashes in its course, one more noticeable than the rest. . . . Thin clouds of smoke and vapor followed in the track of the meteor. . . . From one and a half to two minutes after the dazzling, terrifying, and swiftly moving mass of light had extinguished itself in five sharp flashes, five quickly recurring reports were heard. The volume of sound was so great, that the reverberations seemed to shake the earth to its foundations; buildings quaked and rattled, and the furniture that they contained jarred about as if shaken by an earthquake; in fact, many believed that an earthquake was in progress. Quickly succeeding, and blended with the explosions, came hollow bellowings and rattling sounds, mingled with clang, and clash, and roar, that rolled away southward, as if a tornado of fearful power was retreating upon the meteor's path."

From accounts collected from eye-witnesses by Professor Leonard and Mr. Irish, I conclude that the meteor when first seen was not *less* than sixty miles high over Northern Missouri; that it descended at an angle of about 25° with the horizon, in a right line, and disappeared at a height of five or ten miles. Those in the east, as at Keokuk, saw it low in the west. From St. Louis it was seen in the northwest. In the western part of Iowa it was seen to pass north across the eastern sky. To persons in the north it passed straight down on the southern sky, while to those under the path named it passed nearly overhead, rising in the south and southwest and descending in the north northeast. The path thus determined is at least 120 miles long, and was passed over in a few seconds, probably not over ten. The country near the explosion was prairie or alluvial, where stones on the surface are rarities, and about 800 lbs. of stones like this one, nearly 200 in number, have been picked up in a region seven miles by four, a little east of the end of the meteor's path. These are all supposed to come from the meteor.

Some were picked up on the surface of the frozen ground. One was found on the top of a snowbank, and about forty feet away were marks of a place where it had first struck the ground. Some were plowed up in the spring. The two largest found, of 74 lbs. and 48 lbs., fell by the roadside, and a lawsuit to settle whether they were the property of the finder as being wild game, or of the owner of the lands adjacent as being real estate, was decided in favor of the owner of the land.

No one saw this stone come from that meteor. But in many cases peculiar stones very like to this one have been seen to fall from meteors, and this is one of a group of about twenty stones belonging to Yale College which were gathered at the places and directly after the time of the fall. They are in the Peabody Museum in a case by themselves, and are about one-tenth of all that has been found.

But though we have no eye-witnesses to speak of its fall and finding, the stone as we look at it tells its own story. This rounded side is not waterworn. From your seats you cannot see them, but over these rounded hills and down these valleys run streaks showing that melted matter has
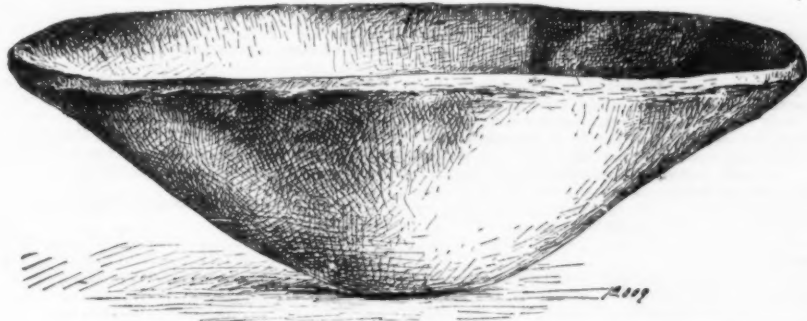

FIG. 34.—DISH FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK.

burial mound, and the two fires that had been made, with the relics found in the ashes, lead to the supposition that it was erected in connection with some peculiar rites celebrated at two periods during its construction. The place may have been the site of an important building. It is very likely that one stood upon the summit of the mound, and that all traces of it have been washed away after the decay of the structure, as would be expected upon such an exposed position.

To the southeast of the large mound was one, marked C on the map, which was nearly 3 feet in height and 47 in extreme diameter, having a slight central depression 26 feet in diameter. On removing the earth, this mound was found to contain sixty stone graves, arranged in the form of a hollow square about the outer portion of the mound, in two or three irregular rows and in three tiers. The graves were carefully made with large flat stones, in the same manner as those I have already described, and were all of large size. The examination showed that, with the exception of one child buried in the same grave with an adult, all the bodies were adults and had been placed at full length in the graves. The grave containing the bones of the child with those of an adult person, was in the lowest tier and among the first made. In this grave was found a large dish made of pottery like the one represented in Fig. 34, and in this dish was the bowl (Fig. 32), reproduced of one-half its diameter. A small discoidal stone (Fig. 33) was also found in this grave

Several of the skeletons showed the effects of inflammatory diseases, and a number of specimens of pathological interest were obtained.

In the middle and upper tiers several graves were found containing relics. In one were portions of an ornament, circular in shape and about 5 inches in diameter, made of two sheets of copper closely united, similar to that found in one of the oldest graves, and, like that, also resting on the breast bone, which, with the ribs, had been discolored and preserved by its contact. In this grave were also three delicate and well made arrow heads and an earthen pot (Fig. 36). In another grave were found three articles of pottery, viz., a vessel with handles, a large dish, and the water jar of a pattern similar to others found and represented by Fig. 37.

A similar jar of slightly different shape (Fig. 38), having the surface divided into portions as if designed after a gourd, was found at the feet of a skeleton.

(To be continued.)

RELATION OF METEORITES TO COMETS.[*]

I HOLD in my hand a stone that weighs about two and a half pounds. Over a part of its surface is a thin black crust. A part of its corners are cracked off, showing a gray interior, and on looking closer you see small points of iron all through it. It is heavy—about one half heavier than granite, or marble, or sandstone. Altogether it is a very curious

FIG. 37.—JAR FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK.   FIG. 38.—JAR FROM GRAVE, BURIAL MOUND WITHIN EARTHWORK.

and is shown of natural size. Near this grave, on the inner side, were found the remains of a body that had not been inclosed in a stone, and this was the only instance of the kind in the mound. The skull belonging to this skeleton was saved. In the lowest tier of graves was one that contained the remains of two skeletons, the skull of which were saved. The only article found in this grave was a dish similar to the one shown in Fig. 34, which is figured.

In another of the graves of this lowest tier, in which the skeleton was much decayed, the following articles were found. A jar at the feet of the skeleton; near it the dish, of which Fig. 34 is a representation, reduced to one-half its diameter. With the bones of the hand was a pipe made of sandstone, which is shown of full size by Fig. 35. In the

stone, totally unlike any of our rocks. That stone was once a part of a comet.

Do you want my reasons for saying it? Or, does any one doubt it? I propose to-night to give those reasons; to set in order, as clearly and simply as I can, the facts and lines of thought that lead me to say as I did—that stone was once a part of a comet.

It came to us from Iowa. Three years ago, on February 12, about ten o'clock in the evening, the light of a bright meteor was seen by nearly everybody then in the open air in the southeast part of that State. I will quote from a vivid description of the meteor given by Mr. Irish, a civil

[*] A lecture delivered in the Mechanics' Course at the Sheffield Scientific School of Yale College, by Professor H. A. Newton.

flowed over them. On two of the smaller sides is collected a real lava deposit, giving in smallest miniature the twisted gnarled forms that some of you have possibly seen in the large lava beds at the foot of the cone of Vesuvius. This other surface had just begun to be melted, as though the fracture that formed it had been made late in the meteor's flight. This larger face is only smoked, and we might even doubt whether the stone had not been broken here after its fall. But the rounded edges of the thin black crust at the angles of the stone show clearly that, except perhaps at some of the corners, the stone was in its present shape when it struck the ground.

Now what caused that brilliant light, that terrific explosion which was heard for forty miles around, that rain of

stones? The only explanation which we can admit is, that a stone weighing not less than 800 lbs.—how much more we know not—perhaps two, perhaps fifty times as much, came into the air from without.

What ought to happen upon the passage of such a stone through the air? At the height of thirty to eighty miles, the region where the meteor tracks are most frequently seen, the air is very rare, rarer than in the so-called vacuum of an air pump. Yet the rapid velocity of the stone condenses the air in front of it.

If we admit the truth of the kinetic theory of gases, we must regard the molecules of air as in rapid motion, each molecule driven this way or that, coming in contact with and bounding back from other molecules. The average velocity of these dancing molecules of air at usual temperatures is a fraction of a mile per second. They, therefore, bound back from any heavy body that moves only a few hundred feet per second, only slightly checking its velocity. But the air is here met by a stone moving, say fifty times as fast as the average molecule. The molecules are driven together beyond the possibility of getting away, until the temperature of the air is raised enormously. Probably the air is liquefied by the pressure, and then pushed aside by main force till the meteor has passed, when it is driven back again into the vacuum behind, giving us a flame shaped like that of a candle.

What effect has all this on the stone? It is solid and firm, as you see, and can withstand not a little pressure. It is not, therefore, heated within, but on the outside it is in contact with, or rather rubbed hard against an intensely hot stratum of air. It is, therefore, melted off just as a piece of tallow would be melted if drawn across a white hot iron. There is no time for the heat to pass by conduction deep into the stone. The melted matter is wiped off by the air. A part clings to these hinder faces of the stone, but the far greater portion helps to make up the meteor's train. It is scattered in eddying currents in a long, narrow, whitish cloud, at first straight, then twisted. That cloud broadens and floats away in contorted forms, remaining visible sometimes a second, sometimes an hour even. The pressure and the heat generally keep cracking the stone, just as any stone is cracked by pressure, or when thrown into a hot fire.

Parts may survive this treatment and reach the ground. Those who have picked them up as they fell have generally said they were hot, as they must be on the outside. But some have been found, it is said, that were very cold. This, too, we may well believe, for they should retain in their interior the intense cold of space.

This stone in my hand shows the breaking up, one fracture being very clearly more recent than another, and if you were near me you might even see fractures that were begun but not ended when the stone reached the ground. On the wall is a picture of the principal explosion of the Iowa meteor, as given by one who saw it, representing, it may be, the cracking when this fragment was broken off from the main mass. There is also one of a meteor seen in Greece in 1863 by Dr. Schmidt. He was standing on the roof of his house in Athens when he caught sight of a magnificent fireball, moving so slowly, that he was able to turn his telescope upon it. The head had two main parts, which were chased by a motley troop of followers, each drawing a bright line on the sky, all of which, at a distance of three or four degrees, melted into a reddish cloud of light. Often a meteor is to the naked eye made up of a group of smaller ones, the whole being like a flock of birds.

I have traced back the history of this stone to its entrance into the air on February 12, 1875, when it was part of a mass of not less than two feet, and I suspect not more than ten feet each way. It looked larger, but men saw the flame around the stone, not the stone itself. By itself, and strictly taken, this history has gaps, but taken along with the history of like stones and meteors that are numerous in the records of science, the story is easily filled out as I have given it above. No scientific man to-day would question it.

The next step in my argument, though admitted by most, is not admitted by all of those whose opinions in this matter are entitled to special respect. I am not aware, however, that anybody has given any formal reasoning against it. I claim that between this stone producing meteor of Iowa and the faintest shooting star which you can see on a clear night in a telescope there is no essential difference as to astronomical character. In all their characteristic phenomena there is a regular gradation in the meteors from one end of the line to the other. They differ in bigness, but in their astronomical relations we cannot divide them into groups. They are all similar members of the solar system.

To prove this, we must of necessity rehearse the points in which the large and small meteors are alike and unlike.

First. They are all solid bodies. The Iowa meteor sent down these stones, and we know that they are solid. This other stone which I show you is one of about 4,000 which fell from a meteor in Poland in 1868, and this you can see is solid. In the Peabody Museum is a goodly collection of such stones from other meteors.

A year ago last December, early on the evening of the 21st, a meteor entered the air sixty miles or more in height over the northwest corner of the Indian Territory, or it may be still farther west. It crossed at a height of between sixty and thirty miles the States of Kansas, Missouri, Illinois, Indiana, and Ohio, and passed on over Lake Erie and the State of New York. No sound was heard, so far as I know, in the State of Kansas, but in Missouri and, still more, in Illinois, the explosions were fearful, and multitudes of fragments were seen to fly off by every one who saw the meteor. In Indiana it was thought that the explosions were heard at Bloomington, 150 miles from the nearest point of the path. In New York State the sky was wholly overcast, so that, of course, nothing was seen, but at many places the people thought there was an earthquake.

Was this a solid body? As if to remove this from the class of detonating into that of stone producing meteors, one single small fragment, three-fourths of a pound in weight, was heard to fall and was picked up the next morning on the snow in Indiana. A piece of this is in the Peabody Museum.

In 1860 a meteor went northwest across Georgia and Tennessee and exploded, disappearing nearly over the southern boundary of Kentucky at a height of about twenty-eight miles. There was the same terrific explosion heard, the same scattering of fragments seen. The meteor was seen over all the region from Pittsburg to New Orleans, and from Savannah to St. Louis, but from this meteor no stone was found, but you cannot doubt for all that that it was a solid body.

So, a few weeks ago, a meteor fell in broad daylight in Southern Virginia, the sound of which, over a limited region, seemed like an earthquake. It, too, must have been solid.

In July, 1860, some of you, I presume, saw a meteor cross from the west to the east. It came from over Northern Michigan, and was seen until it had passed at least 200 miles east of us, passing between us and New York city at a height of a little more than forty miles. One pear shaped ball chased a second and a third across the sky. People listened for the sound to come, and one or two thought they heard it, but would not affirm that it was sound from the meteor. I cannot doubt that that, too, was solid. It was seen to break in two, and the parts passed on one after the other for hundreds of miles. To be sure no stone was found from it, and perhaps no sound heard, yet that it was solid seems to me almost as sure as if I had a piece of it in my hands.

Again, going one step farther, how can we avoid calling all the meteors solid which are seen to break into pieces, and all those which glance, describing a curved course, or a course having an angle? The number of such cases is large, and often they are very faint shooting stars. But it is doubtful whether a small gaseous mass could exist permanently as a separate body in the solar system. Its repulsion would keep the parts so far asunder that the sun's unequal attraction would scatter the substance beyond all its own power of recovery. A liquid would probably freeze and become solid. In any case neither a gas nor a liquid could for an instant sustain the resisting pressure which a meteor is subjected to in the air, much less could it travel against it ten, or forty, or a hundred miles. In short, every shooting star must be a solid body.

Second. The large meteors and the small ones are seen at about the same height from the earth's surface. The larger meteors may become visible a little higher than shooting stars, though that is doubtful; they come down in general a little lower; some of them even come to the ground, but that is due rather to the size of the body. The air is a shield to protect us from an otherwise intolerable bombarding. Some of the larger balls come through that shield, or, at least, are not all melted before their final explosion, when the fragments, their original velocity all gone, fall quietly to the ground. The small ones burn up altogether, or are scattered into dust.

In the third place, the velocities of the large and small meteors agree. These velocities are never very exactly measured directly, but we are sure that in general they are more than two and less than forty miles per second. This is true both for small and for large meteors. The average velocities for each class are not widely different.

We sometimes need a name for the small body that will, if it should come into the air, make a shooting star or larger fireball. We call such a body a meteoroid. Now velocities of from ten to forty miles a second imply that the meteoroids are bodies that move about the sun as center, or else move through space. These velocities, as well as other facts, are utterly inconsistent with a permanent motion of the meteoroids about the earth, or with a terrestrial origin, or with a lunar origin.

Fourth. The motions of the large and small meteors, as we see them cross the sky, have no special relations to the ecliptic. If either the one or the other kind had special relations to the planets in their origin or in their motions, we should have reason to expect them, if not always, at least in general, to move across the sky away from the ecliptic. But the fact is otherwise. We see both small and large meteors move toward the ecliptic as often as from it. Neither class seem, therefore, to have any relation to the planets.

Again, in general character the two classes are alike. They have like varieties of color; they have similar luminous trains behind them; in short, we cannot draw any line dividing the stone producing meteor from the shooting star, at least in their astronomical relations. We cannot say that the Iowa meteor is different from the Georgia meteor of 1860, on the ground that stones were found in one case and not in the other; or that the meteor of December, 1876, was different from that of July, 1860, on the ground that one had a series of terrific explosions, and the other was only seen to break into parts; or that the meteor that is seen to break into parts differs from one evidently solid, that burns up without any appearance of explosion. They all are astronomically alike. They differ in bigness, but this has nothing to do with their motion about the sun or in space.

When, therefore, we learn something about the origin and motions of the smaller meteoroids, we can infer like facts about the larger ones. I propose, then, to show that shooting stars were once pieces of comets.

There are two classes of shooting stars, which have been sometimes spoken of as unlike, but which are now admitted on all hands to be of common origin and character, namely, those which come in quantities on certain nights of the year, and give what is called a star shower, and the sporadic meteors, such as we can see on any clear night.

In November, 1799, Von Humboldt saw during his travels in South America a shower of shooting stars, and he has given a glowing description of the sight. These came on the morning of November 12. In 1832, November 13, there was seen in Europe a display of less brilliancy. It, however, attracted not a little attention, as descriptions and newspaper notices show in every country in Europe. But no person seems to have connected it with any previous shower, nor does it appear that any one gave a hint of the true nature of the phenomenon.

The next year there appeared in this country, on the morning of November 13, a more brilliant shower, which some present doubtless witnessed. Through the morning hours of that day the stars shot across the sky like the flakes of snow in a snowstorm. Not a little difference was there in the way people looked at it. The negroes at the South thought the day of judgment had come. The owner of a plantation told me that his negroes had gathered in the "praise house," and that he, on being waked, went down to quiet their fears. They had concluded not to call "Missus," as she would soon hear Gabriel's trumpet, and they well knew that she was ready to go. A student here in college was going to prayers, and saw a ball of light pass across the half lighted moving sky. He rubbed his eyes, thinking that something was the matter with them. A second flight made him sure that his eyes were troubled, and he looked down and hurried on to chapel. A servant girl by chance returning home in the early morning, saw it, but said nothing until it was talked of the next day. "Oh!" said she, "I saw that." "Did you? Why did you not call us?" "Really, I didn't know but that the stars went out that way every morning."

Professor Twining saw it, and observing that all the flights were away from one point in the heavens, and that that point moved along with the stars as they rose in the morning sky, he said, "These are not, as some say, meteorological phenomena; they are not, as others say, electric; these are bodies coming to us from beyond the air, and they belong to astronomy."

This was the first definite proof of the cosmic origin of meteors.

Nine hundred and thirty-one years earlier, that is, in the year 902, there was a like brilliant shower of fire. A cruel Aghlabite king then reigned at Tunis. He had driven the Christians out of Sicily, penning up the Bishop of Taormina and the remnant of his people in the church, and burning it and them together. He had crossed to the mainland, and was besieging Cosenza, then an important city of Calabria. He suddenly died, and the flying monks were relieved of their terrors. They connected his death with the star shower which occurred at or near the same time; and in all the annals it is repeated in various phrases that on the night when King Ibrahim Bin Ahmad died an infinite number of stars scattered themselves like rain to the right and left.

Between the years 902 and 1799 the November meteors were seen in unusual numbers in at least nine different years. The showers in the table which I show you are not selected out of an indefinite number in our histories. On the contrary, they are nearly all which we have found in the records as having occurred near that time of year.

EPOCHS OF NOVEMBER STAR SHOWERS.

Year.		Day.
902	....	October 13
931	....	" 16
934	....	" 14
1002	....	" 15
1101	....	" 17
1202	....	" 19
1366	....	" 23
1533	....	" 25
1602	....	" 28
1698	....	November 9
1799	....	" 12
1832	....	" 13
1833	....	" 13
1863–68	....	" 14

Notice now in this table that the showers came either near the beginning or near the end of the first third, or else near the end of the second third of the century; in other words, they all come near the end of a cycle whose length was 33¼ years. Again, notice that the day of the month advanced with slight irregularity about three days in the century. The large advance of twelve days between 1602 and 1698 is due to the change of ten days in the reckoning in passing from old style to new style.

I have added, as you see, the six years from 1863 to 1868, in each of which, but especially in the latter three, these meteors came, as we had expected, on the morning of November 14. They seemed in all these years to pass, as they did in 1833, across the sky, as though going away from the constellation Leo, or rather from the sickle in Leo. This means that the small bodies really came into the air in parallel lines, the apparent radiation being the way in which parallel lines appear to us. There can be no doubt that here was the same parallelism of paths in all the earlier star showers.

Here we have a group of solid bodies coming into the air all moving in one given direction. They come to us only on a particular time in the year, for the slow change from the middle of October to the middle of November can be explained. They come to us only at intervals of about a third of a century. These facts can only be satisfied by supposing that vast numbers of these small bodies are moving in a long thin stream around the sun, and that the earth, at the proper times, plunges through them, taking into the air each time some scores of millions of them. Each of them must be moving in an orbit having the same period as every other, and approximately the same path.

Now it may be shown that there are but five orbits about the sun that can meet these conditions. Further than that, there is but one of these five that can explain the change of date from the middle of October to the middle of November, and this fifth one does explain the change perfectly. I cannot, in the time you kindly grant me, give, in such detail that you can clearly understand them, the reasons for thus limiting the path of the meteoroids first to five possible orbits, and then to one of these five. I must ask you to accept the statement in view of the fact that no astronomer has, so far as I know, ever questioned the proofs of it.

That orbit is one which is described in 33¼ years. The meteoroids go out a little further than the planet Uranus, or about twenty times as far as the earth is from the sun. While they all describe nearly the same orbit, they are not collected in one compact group. On the contrary, they take four or five years to pass a given place in the orbit, and are to be thought of as a train several hundred millions of miles long, but only a few thousands of miles in thickness.

Now right along with this train of meteoroids travels a comet. It passed the place where we meet the meteoroid stream nearly a year before the great shower of 1866, and two or three years before the quite considerable displays of 1867 and 1868. It was, therefore, well toward the front in the great procession.

How came it that this comet and the meteoroids thus travel the same road, the comet with the meteoroids, and the meteoroids with each other? The plane of the comet's orbit might have cut the earth's orbit to correspond with any other day of the year than November 15. Or, cutting it at this place, the comet might have gone nearer to the sun or farther away. Or, satisfying these two conditions, it might have made any angle from zero to 180°, instead of 167°. Or, satisfying all these, it might have had any other periodic time than 33¼ years. Even then it might have gone off in any other direction of the plane than that in which the meteoroids were traveling. All these things did not happen by chance; there is something common.

The comet which I have named is not the only one that has an orbit common with meteoroids, though it is the only case in which the orbit of the meteoroids is completely known, aside from our knowledge of that of the comet. Every August, about the tenth day, we have an unusual number of meteors—a star sprinkle, as it has been called. A comet whose period is about 125 years moves in the plane, and probably in a like orbit with these meteoroids.

So near the first of December we have had several star showers—notably one in 1872—and these meteoroids are traveling nearly in the orbit of Biela's comet. In April, too, some showers have occurred which are thought to have had something to do with a known comet.